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J. F. Coates, Inc.
Washington, DC

Prepared for

Environmental Protection Agency
Washington, DC

Apr 82

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ENVIRONMENTAL CONSEQUENCES OF TELEMATICS: TELECOMMUNICATION, COMPUTATION, AND INFORMATION TECHNOLOGIES

by

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Contract No. 68-02-3667

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Current important research needs whose results will be critical to EPA's mission in the next two to three decades with regard to a major expansion in the use of telematics, i.e. telecommunications, computer, and information technology, are identified.

The potential benefits of telematics to the economy, the environment, and to health and safety are very large and numerous. Benefits will far outweigh the potential social costs. Most of the benefits of telematics are likely in the long run to be provided by the private sector.

The four most important potentially undesirable impacts of telematics which are poorly understood are:

- microwave radiation;
- indoor pollution, ozone, and other materials produced by telematics equipment;
- solid waste disposal of toxic materials in telematics devices at the end of the use cycle;
- human factors, design failures, and psychological and physiological stress in the modern telemated office.

There are three classes of meta-impacts which would result from the large-scale, pervasive use of telematics in American society, each of which could, in itself, have far more important environmental impacts than any other effects. Primary and secondary research needs are defined with regard to these and other risks and opportunities.

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PREFACE

As a key element in anticipating new or newly important environmental problems, the OSASS of the U.S. Environmental Protection Agency began a mini assessment program. Collectively, the reports under this program are intended to:

- produce a description of alternative future trends and contingencies, and an analysis of the environmental consequences, including effects on public health, the vitality of natural systems, socioeconomic considerations, public welfare and policy implications;
- identify research which should be conducted to support the agency's regulatory mission over the longer term future.

The generic objectives of the mini assessment program, as stated in RFP DV-80-A150, are to assist OSASS by producing a report which will:

- provide a comprehensive, integrated overview of the longer term regional, national, and global environmental outlook;
- expand existing data bases and increase understanding of potentially significant future problems;
- evaluate concepts, models, methods, and environmental controls and policies as they affect the environmental future.

The specific function of each mini assessment will be to explore a potentially significant future environmental problem, and from that exploration produce a report:

- summarizing the state-of-knowledge concerning the problem;
- defining and scoping the problem in terms of its public health, public welfare, and environmental policy implications;
- identifying major information/knowledge gaps and inadequacies in analytical methods and techniques.

We are pleased to be associated with this intellectually and administratively exciting venture. We are doubly pleased to have enjoyed a singularly collegial relationship with our program officers, Morris Levin, James Regans and Basil H. Manns, and to have benefited from refreshing exchanges at the scientific and administrative level with the management and staff of their office.

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John M. Richardson has consulted with us on this project.

Terry Saunders Parsons administered and managed the production of materials in the first half of this project. Rhoda Baum managed the production of this report. She was assisted by Bernice Mann, Barbara Bullard, Margaret McDonald, Kerry Siggard, and Lea Singer.

The participants in our workshop and others who helped us with information or in review are acknowledged in Appendix B.

Grant Prillaman was especially helpful in research assistance toward the end of this project.

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ABSTRACT

Current important research needs whose results will be critical to EPA's mission in the next two to three decades with regard to a major expansion in the use of telematics, i.e. telecommunications, computer, and information technology, are identified.

The potential benefits of telematics to the economy, the environment, and to health and safety are very large and numerous. Benefits will far outweigh the potential social costs. Most of the benefits of telematics are likely in the long run to be provided by the private sector.

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There are three classes of meta-impacts which would result from the large-scale, pervasive use of telematics in American society, each of which could, in itself, have far more important environmental impacts than any other effects. Primary and secondary research needs are defined with regard to these and other risks and opportunities.

This report was submitted in fulfillment of Contract No. 68-02-3667 by J. F. Coates, Inc. under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from December 11, 1980, to September 15, 1981, and work was completed as of April 22, 1982.

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EPA-287 (Cin.)
(4-76)

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CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD, BEGIN SECTIONS HERE

CONTENTS

Preface iii
Abstract v
Contents vi
List of Exhibits viii

1. Summary, Findings & Recommendations 1
   - The Pace of Telematics Development 2
   - The Search for Impacts 3
   - Stakeholders 5
   - Findings and Conclusions 8
   - Recommendations 9
   - Afterword 13
2. Assessing Telematics Technology 14
   - Introduction 14
   - The Pace of Telematics Development 15
   - The Search for Impacts 17
   - Assumptions and Definitions 21
   - What Follows 22
3. Telematics: Telecommunications, Computer, and Information Technologies in Collision, Convergence, and Coalescence ... 24
   - Introduction 24
   - What Telematics Does 25
   - The Telematics Tinker-Toy 27
   - Basic Devices Widely Available Before 1960 27
   - Devices Available in the Early 1970s 29
   - New and Emerging Devices Around the 1980s 31
   - Some Significant Systems and Software Developments 36
   - Ancillary Devices 40
   - Big Telematics Systems 41
   - New Capabilities 44
   - Social Characteristics of New Telematics Capabilities 45
4. The Societal Context of Telematics: Long-Range Trends 48
   - Why Look at the Social Context 48
   - Trends Pushing and Inhibiting Telematics Adoption 50
   - Trends Related to the Environment, EPA's Mission, and Telematics 53
5. Impacts of Telematic Technologies 59
   - Introduction 59
   - Possible Impacts on the Biota 61
   - Possible Impacts on Human Health and Safety 68
   - The Special Case of Microwave Radiation 75
   - Impacts on the Technoeconomy 80
   - Social Discontinuities 92

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

CONTENTS, continued

Which Impacts are "Most Important"? Criteria for Sorting....... 93

6. Issues and Stakeholders.. 100
   - Why Any EPA (or Government) Role with Regard to Telematics?..... 102
   - Major Stakeholders: Objectives and Environmental Interests..... 104
   - Potentially Affected Parties................................. 116
   - Factors Influencing the Dissemination and Use of Telematics..... 119
   - Some Implications for EPA..................................... 127

7. Findings and Conclusions.. 129

8. Recommendations... 135
   - Recommendations to EPA.. 135
   - Broader Federal Response to Which EPA Could Make a Strong Contribution Include:.. 138

References.. 140

Appendices

A. Annotated Bibliography on Telematics........................... 147

B. Methodology Use in the Study.................................... 174

EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

EXHIBITS

Number		Page
1-1	Telematics Devices and Systems	4
1-2	Trends Driving and Inhibiting Telematics	5
1-3	Telematics--Opportunities and Problems	6
1-4	Latent Interests of Affected Parties	7
2-1	Impact of Technology Innovation on User Institutions	18
2-2	How Telematic Systems May Impact the Environment	19
2-3	Elements of a Telecommunications System	20
3-1	Telematic Devices Widely Available Before 1960	28
3-2	Telematic Devices Widely Available by the Early 70s	29
3-3	Telematics Devices Now and Emerging in the 80s	32
3-4	Some Significant Systems and Software	37
3-5	A Broadcast Teletext System	38
3-6	A Videotex System	38
3-7	Ancillary Devices	40
4-1	Trends Driving and Inhibiting Telematics	51
4-2	Trends Relating Telematics to EPA's Mission	54
5-1	Telematics--Opportunities and Problems	62
5-2	Nontravel Substitutes That May Satisfy Travel-Generating Person-to-Object Interactions	66
5-3	Biomedical Telematic Instruments	74
5-4	Radio Frequency Bands	76
5-5	Map-Total Population Increase by Region, 1970 to 1980	82
5-6	Classes and Causes of Future Environmental Problems	95
5-7	Basic Causes of Future Environmental Problems	97
6-1	Stakeholders and Potentially Affected Parties	110
6-2	Labor Unions With an Interest in Telematics	113
6-3	Telematics Health Hazards--A Vignette	114
6-4	Congressional Committees with Interests in Telematics	117

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA: OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

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BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD BEGIN SECTIONS HERE

EXHIBITS, continued

Number Page

6-5 Latent Interests of Affected Parties........................ 120
6-6 Telegraphy's Progressive Consolidation into Monopolistic Clusters.. 123
B-1 Phased Demand Matrix for the Identification of Potential Impacts.................................... 175
B-2 Methods Use for Identification of Impacts.................... 177
B-3 Participants in the Mid-Project Workshops.................... 180
B-4 Participants in Review Workshop.............................. 182

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9-1/8"
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BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

SECTION 1

SUMMARY, FINDINGS & RECOMMENDATIONS

As a key element in anticipating new or newly important environmental problems, the Office of Strategic Assessment and Special Studies of the U.S. Environmental Protection Agency began a mini assessment program designed to provide a comprehensive, integrated overview of the longer term regional, national, and global environmental outlook with respect to certain potential problems. The mini assessments are to summarize the state of knowledge concerning the problem, scope the problem in terms of its implications for public health and welfare and environmental policy, and identify major information gaps and inadequacies in analytical methods and techniques. This mini assessment is concerned with the impending revolutionary consequences of telematics technology in the next 25 years. We use the term "telematics" to mean the convergence of computer, information, and telecommunications technologies. See Section 2.*

As used in this report the term "telematics" carries no political or ideological connotations. It is a convenient expression for three merging lines of technological development.

The project did not undertake original field or laboratory research. It relied upon examination, collation, and analysis of the published research findings of others. A synthetic and critical examination of those reports is intended as our contribution to the policy and research planning discussion. This report used review by experts and potentially affected parties in a broad outreach process to collect, correct, and organize materials and critique findings and recommendations.

The assessment's primary concern is environmental impacts, but it is not, and could not be, limited to environmental impacts. The likely consequences of telecommunications in the future are so broad, complex, and diffuse that many of the social and economic effects could, in turn, hold implications for environmental quality and for human health and safety.

The assessment concludes that on balance the effects of telematics on environmental quality should be strongly positive—that is, beneficial. The capabilities which telematics can provide for monitoring environmental quality, for detecting and tracing pollutants, and controlling them at the source, and for diagnosis and treatment of disease and injury (including those of

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* The section(s) expanding on points in this summary are so noted.

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environmental origin) will be invaluable.

There are some possibly significant environmental problems associated with increasing use of telematics. The most important of these concerns, which are just emerging into public awareness, are the possible adverse effects of microwave radiation. At present, scientific knowledge is not sufficient to determine reliably the scope or seriousness of the hazards and risks from electromagnetic radiation. More research is needed in several areas which probably fall within EPA responsibility.

There can be little doubt that telematics, in the future, will bring about significant technoeconomic changes. The continuing growth of electronic industries, their integration with communications industries, a new wave of industrial automation (including industrial robots and related technologies), and, most importantly, the uncertain and controversial effects on the location of people and industry will surely have long-range implications for environmental change, protection, and management. This report suggests what some of the secondary environmental impacts may be and identifies trends which should be monitored as part of EPA long-range research planning. It concludes that in population decentralization telematics is a facilitator rather than a driving force, and that while decentralization would relieve some current environmental problems, it could make others more difficult to monitor and control.

Most of the potential benefits of telematics will be captured through the workings of the market without government intervention. However, efforts by EPA and other agencies acting cooperatively with industry and public interest groups could stimulate innovation and encourage timely applications of telematics for the meeting of public sector needs and national objectives.

THE PACE OF TELEMATICS DEVELOPMENT

Telematics applications can either substitute for or supplement a broad range of basic technologies and productive activities and at the same time add capabilities which do not now exist. Nothing short of a "doomsday scenario" would prevent the increasing adoption and use of telematics in the long run. The major impacts on society, which will mature around 1990-2010, will come from exploitation of new capabilities offered by telematics which are common to several subsets of technological developments (Exhibit 1-1).

Revolutions driven by technology do not come about overnight. Change will be driven by a steady, rolling accumulation of small modifications resulting in a body of irreversible differences in the way we organize our personal and collective affairs. Technologies will be introduced in different forms and for difference purposes, as substitutes to improve old processes or to perform new functions. The cumulative effect will be to remake our world. See Section 3.

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THE SEARCH FOR IMPACTS

It is fairly straightforward to anticipate some highly credible consequences of telematics technology. Many have speculated, for example, that telecommunications may substitute for transportation and thereby improve the environment by reducing the use of automobiles. Air pollution and the raw material and waste disposal side of our industrial cycles could be affected. As we substitute information technology for other kinds of basic labor, workplaces may become cleaner and safer. As telecommunications networks permeate society we may be more readily able to respond to medical emergencies, fires, accidents, and natural disasters, and to improve the health and well-being of our citizens.

The random generation of significant implications of technology is one route to understanding the future, but it is not a sufficient basis for coming to grips with a potentially limitless number of changes. We need a strategy for search and sort. The strategy adopted in this paper is to take lessons from what we know about the major and minor effects of other technologies and to use those generalizations as search rules for probing the future. The dominant effects of technologies come about in the following general ways:

- Technology itself will produce effects. The individual elements of telematics technology must be manufactured. They require raw materials; they must be shipped, stored, used, and disposed of.

- The individual elements of the technology join to form systems. A system has its own implications for the environment in terms of its initiation, planning, construction, operation, maintenance, and final decline and disposal.

- New technologies may substitute for older technologies and will have effects through what is removed from the market.

- The capabilities to do new things or to do old things better are implicit in every new technology. Those capabilities which can have environmental effects include:

  -- new control over time and space,
  -- new power to obscure and mislead,
  -- new extensions of human capabilities,
  -- new levels of efficiency and productivity,
  -- new power to connect and disconnect,
  -- new power to centralize and decentralize.

- Trends outside the areas of telecommunications will interact with telecommunications in ways that cannot be discerned solely from the technology itself. These facilitating and inhibiting trends are summarized in Exhibit 1-2. See Section 4.

Some principal impacts on the environment, health, and safety are shown in Exhibit 1-3. See Section 5.

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EXHIBIT 1-1: TELEMATICS DEVICES AND SYSTEMS

TELEMATIC DEVICES WIDELY AVAILABLE BEFORE 1960

- Telegraph
- Telephone
- Microwave transmission
- Radio (AM/FM)
- Television (B/W)
- Facsimile
- Phonograph
- Tape recording
- Xerography
- Cable (one-way)
- Transponders
- Typewriter
- Movies
- Still Photography (B/W, color)
- Polaroid
- Microfilm
- Robots - first generation
- Mainframe computers

TELEMATIC DEVICES WIDELY AVAILABLE BY THE '70's

- Touchtone pad (push button keyboard)
- Call forwarding
- C.B. radio
- Picturephone
- Portapack video recorder, the minicam
- Color television
- Portable television
- Frame grabber
- Slow scan
- Private microwave transmission
- Audio cassette
- Low cost xerography.
- Two-way cable television
- Electric typewriter
- Geophysical Satellites
- Optical scanner
- Microfiche
- Robots - second generation
- Hand Calculator
- Minicomputer
- Central processing unit memory

Telematic Devices Now & Emerging in the '80's

- Microprocessor
- 800 numbers
- Voice answer back
- Voice activation
- Low cost video recorders
- Video discs
- Large screen television
- Laser
- Fiber optics
- Video cassettes
- Electronic scratch pad
- Direct satellite broadcasting
- Word processor
- Graphic & color display
- Speech compressor
- Packet switching
- Robots - third generation
- Microcomputers
- Large scale integrated circuits
- New memory systems:solid state, laser, bubble, backend processes
- Morpheme generator

Some Significant Systems & Software

- Micro home information system
- Computer utilities - Illiac IV, Arpanet, Plato
- Communication satellites - Comsat, Intelsat, ATS-6
- Other space Satellites - ERTS, weather, agriculture
- CAD (computer-assisted design)
- CAM (computer assisted manufacture
- Simulation-modeling
- Aids to the handicapped
- Electronic switching systems (ESS)
- Mobile cellular system
- Information utilities - The Source, Lockheed, Prestel
- Teletext
- Videotex
- Pattern recognition - voice, signature
- Encryption
- PBX self contained telephone exchanges

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(4-76)

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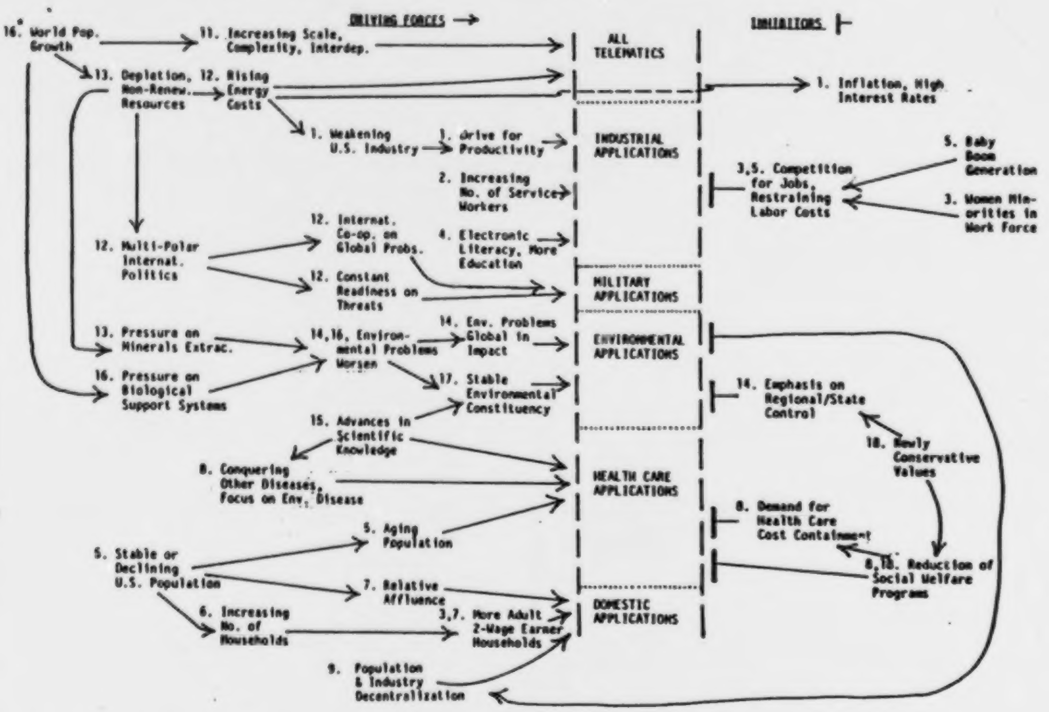
EXHIBIT 1-2: TRENDS DRIVING AND INHIBITING TELEMATICS


DRIVING FORCES →
INHIBITORS ⊢
16.* World Pop. Growth
11. Increasing Scale, Complexity, Interdep.
13. Depletion, Non-Renew. Resources
12. Rising Energy Costs
1. Weakening U.S. Industry
1. Drive for Productivity
2. Increasing No. of Service Workers
4. Electronic Literacy, More Education
12. Internat. Co-op. on Global Probs.
12. Multi-Polar Internat. Politics
12. Constant Readiness on Threats
13. Pressure on Minerals Extrac.
16. Pressure on Biological Support Systems
14,16. Environmental Problems Worsen
14. Env. Problems Global in Impact
17. Stable Environmental Constituency
15. Advances in Scientific Knowledge
8. Conquering Other Diseases, Focus on Env. Disease
5. Aging Population
5. Stable or Declining U.S. Population
7. Relative Affluence
6. Increasing No. of Households
3,7. More Adult 2-Wage Earner Households
9. Population & Industry Decentralization
ALL TELEMATICS
INDUSTRIAL APPLICATIONS
MILITARY APPLICATIONS
ENVIRONMENTAL APPLICATIONS
HEALTH CARE APPLICATIONS
DOMESTIC APPLICATIONS
1. Inflation, High Interest Rates
3,5. Competition for Jobs, Restraining Labor Costs
5. Baby Boom Generation
3. Women Minorities in Work Force
14. Emphasis on Regional/State Control
18. Newly Conservative Values
8. Demand for Health Care Cost Containment
8,18. Reduction of Social Welfare Programs

* Numbers refer to trends. See Trend discussions in Exhibit 4-2.

STAKEHOLDERS

In the long run, it is in the interests of all parties, including the telematics industries, to anticipate, prevent, relieve or solve any environmental, health, and safety problems that may emerge from telematics. In the short run, however, the major actors in telematics development, including Federal mission agencies, have few or no incentives or mandate to search out such problems so that they can be dealt with at early stages of development. The primary stakeholders have few or no incentives for identifying environmental problems before they become undeniably bad problems. This alone justifies, if not demands, that EPA planners carry out broad, exploratory assessments as an early warning system on real problems and as a means to allay any public alarm that is not warranted. The latent interests of some stakeholders in these problems is shown in Exhibit 1-4. See Section 6.

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EXHIBIT 1-3: TELEMATICS—OPPORTUNITIES AND PROBLEMS

	POTENTIAL OPPORTUNITIES/BENEFITS	POTENTIAL PROBLEMS/COSTS
BIOTA	• Monitoring and control mechanisms for air, water, solid waste, noise, radiation pollution control. • Localized traffic control. • Natural resource management (exploration, detection or tracking of minerals, fish schools, herds, forest or crop disease, etc.) • Improved weather monitoring, prediction, and modification. • Reduced pollution from transportation (uncertain).	• Effects of microwave radiation (uncertain). • Future disposal of toxic substances used in some telematics devices.
HEALTH AND SAFETY	• Use of robots in hazardous tasks and hostile environments. • Detection & monitoring of pollutants in workplace. • Detection & monitoring of pollutants in home and office. • Detection & monitoring of pollutants in the environment. • Devices for diagnosis and treatment. • Emergency services coordination and routing. • Remote consultation. • Medical education. • Medical information systems.	• Effect of microwave radiation (uncertain). • Toxic fumes from telematics devices involved in fires. • Ozone emissions. • Physical and psychic stress from VDT. • Increased costs of medical services. • Increased disequities in health care delivery. • Increased impersonality in medical care.
TECHNO-ECONOMY	• Direct economic growth (electronics industry, exports). • Increased productivity in manufacturing, services, agriculture, mining, etc. • Minimization of negative impacts or social dislocations resulting from decentralizations.	• Impact on employment levels (uncertain), reduction of unskilled/semi-skilled jobs in some categories. • Retraining of workers. • Disadvantages for some small, under-capitalized businesses. • Disturbance of relationships between management and labor; erosion of constituency for occupational safety.
TRANS-SOCIAL	• New capabilities in large and diverse fields of activity.	• Systematic vulnerability from reliance on telematics. • Need to develop: structures for synthesis of information, more sophisticated programming; revised laws/regulations to fit new activities and new problems. • Need for national and international information/communication policies.

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EXHIBIT 1-4: LATENT INTERESTS OF AFFECTED PARTIES

Potentially Affected Parties	And Their Latent Interests
• Individuals and households	• Improved interior environments (indoor monitoring, alarm systems) Improved emergency and health care systems Improved prosthesis for the handicapped Improved communication, comfort, convenience, entertainment, etc. Possible impacts on medical care and housing costs Possible impacts of microwave radiation
• Medical and emergency delivery institutions and specialists	• More effective and efficient technology Possibly higher costs Possible reduction in professional independence Increased disparity between large and small institutions
• Local governments	• Improved tools for coordination and control of a variety of public services such as traffic control, disaster response, water and sewer treatment, air quality, crime prevention Possible problems with telematics device disposal (toxic substances) in the future Risk to firefighters from toxic fumes Effects of decentralization of population, industry, and work centers (Facilitated by telematics)
• Designers, builders, building managers	• Degradation of indoor environment; ozone emissions Monitoring of indoor environment Changes in work flow and indoor traffic flow
• Industry: owners, managers	• Improved productivity and efficiency Enlarged market opportunities Labor/automation trade-offs, labor relations Redesign of the work place - transformation of the factory Diverse effects on regulatory costs (OSHA)
• Labor	• Employment levels Skill requirements Occupational safety and health
• Farm owners, farm workers	• Increased productivity and efficiency Advanced market information Increased capital costs; disparities between large and small farms
• Resource development managers • Environmental managers • Disaster response managers	• Applications for monitoring, advance warning, pollution detection, etc.

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FINDINGS AND CONCLUSIONS

The mini assessment resulted in fifteen principal findings and conclusions. They are presented here in compressed form; for further discussion the reader should consult Section 7.

1. The potential benefits of telematics to the economy, the environment, and to health and safety are very large and numerous. Benefits will far outweigh the potential social costs.

2. No government organizations or private sector groups are systematically planning to exploit the environmental benefits of the rapidly proliferating telematics technologies on a scale commensurate with their benefits.

3. Most of the benefits of telematics are likely in the long run to be provided by the private sector. The timely development of positive environmental applications and the prevention of environmental abuse by private initiative alone is far less certain. The most socially beneficial environmental applications should be developed and promoted by the Federal government, especially by EPA.

4. There are some potentially troublesome environmental and health impacts associated with telematics. Their significance is now uncertain. It is not in the self-interest or the legislative mandate of other major stakeholders and actors to call attention to and assess these potential problems. This implies an important role for EPA which is now being neglected. The four most important potentially undesirable impacts of telematics which are poorly understood are:

- microwave radiation;
- indoor pollution, ozone, and other materials produced by telematics equipment;
- solid waste disposal of toxic materials in telematics devices at the end of the use cycle;
- human factors, design failures, and psychological and physiological stress in the modern telemated office.

5. The failure of the Federal government, and EPA particularly, to act in a timely, unequivocal, judicious manner on microwave radiation's effects could substantially inhibit the enormously productive application of telematics to the American economy by encouraging the proliferation of vast numbers of incompatible local and state rules and ordinances.

> The adverse effects on the economy of equivocation and uncertainty would be a major economic setback. It should further be noted that in many of the applications where microwaves could be employed there is an alternative technology—fiber optics.

Consequently, acting in an early and timely fashion would clarify productive development and innovation in the area of telematics.

6. Telematics is a facilitator rather than a primary driver in decentralization of population and industry.

7. Public support for environmental protection will fluctuate but is likely to remain strong and to grow in the long run. Changes in national priorities and political attitudes will, however, require a more flexible and innovative strategy for carrying out EPA missions in telematics.

8. The environmental problems and opportunities of telematics cut across the institutional lines within EPA and the jurisdictional lines of EPA and other Federal agencies.

9. The best evidence is that telematics does not motivate people to reduce travel to any significant degree, other things being equal. But if travel is cut back for other reasons, telematics will moderate the social disruption and inconvenience which would otherwise occur.

10. The telematics industries consume energy and materials in manufacturing and in providing services. In general, however, the industry itself appears environmentally benign.

11. The biggest effects from telematics will result indirectly from substitution and from new capabilities.

12. A federal role with regard to telematics is necessary and inevitable, but it need not be, and should not be, a dominant role.

13. There are three classes of meta-impacts which would result from the large-scale, pervasive use of telematics in American society, each of which could, in itself, have far more important environmental impacts than any other effects we have come upon.

14. EPA has a unique and necessary role to play in researching and assessing the potential positive and negative impacts on society of the telematics revolution.

15. The United States military and national security system is fully committed to telematics. The implications of that intensive involvement and dependency on telematics technology in peacetime, in a conventional war, or in case of a nuclear exchange, is outside the scope of the present study, but it is of such prime importance as to merit independent analysis.

RECOMMENDATIONS

The first group of nine recommendations coming from this assessment are intended for EPA, the sponsor of this assessment, and specifically for the Office of Research and Development. The report should also serve a larger audience. Therefore, there are three additional recommendations which involve actions in which EPA could not be the primary actor but should play a strong supporting role. See Section 8.

In addition to the obvious criterion of importance, the recommendations reflect two dominant considerations—government's role and EPA's role in affecting the environment, health and safety, and the technoeconomy.

Government's Role. Recognizing that we are talking about long-term effects and major outcomes, we see that the government role on these long-term matters should be driven by two questions. Will the failure to act be highly likely to cause:

- an undesirable outcome?
- a potential social benefit to be lost?

EPA's Role. As an agency of government reflecting the above criteria in more detail, EPA's direct role in telematics relates to these considerations:

- Is the problem unequivocally outside EPA's mission?
- Is the issue tractable by EPA's major forms of action?
- Is new knowledge likely to inform those actions?
- Can that new knowledge be related to specific EPA R&D and information activities such as—
  - research
  - development
  - monitoring
  - evaluation
  - public information
  - knowledge transfer
  - constituency building, inside and outside the government.

The application of these criteria lead to recommendations for EPA's research program which concentrate on new developments and second order impacts and consequences, and soft pedal research in those effects which are only marginal additions to existing or already known problems, or which, at worst, have self-limiting or only highly localized impacts.

The Recommendations To EPA

1. EPA should continue and expand its role in exploratory research and assessment of the societal implications and potential impacts of telematics.

2. EPA should accelerate its address to the questions of microwave radiation effects and coordinate its work more tightly with FCC, the Armed Services, industry, and others concerned with this matter.

3. EPA should conduct further research and assessment on the impact of telematics on the indoor environment.

4. The human factor elements in the telemated office and factory of the future will become increasingly pressing and urgent. Further research on the human factor considerations, including body shape and size, the body in motion, and the body at work, should be begun immediately in conjunction with NIOSH and representation from labor and industry.

5. EPA should assess and monitor the ultimate disposal of telematic devices.

6. To accelerate the positive use of telematics for environmental enhancement, EPA should exhaustively review, within the framework of its established programs and missions in air, water, solid waste, noise, and toxic substances:

- the extent to which telematics are now used or available for environmental monitoring and control;
- specific needs and requirements which could be met, now or potentially by telematics;
- design criteria which would be necessary for telematics to fill such needs;
- the likely effects of more extensive telematics use in carrying out mission and program responsibilities;
- costs or cost savings from the use of telematics;
- internal or external inhibitors to use of telematics for environmental protection.

7. Information generated by this review should be systematically shared through a handbook and other information mechanisms with:

- telematics producers and service providers;
- industries looking for cost-effective ways to reduce pollution;
- natural resource managers in Federal, state, and local agencies;
- environmental interest groups;
- the interested public.

8. As a short-term and highly productive stopgap measure, EPA could initiate a program to prepare software packages on environmental matters usable on mini- and micro-institutional and personal computers.

EPA-287 (Cin.)
(4-76)

9. EPA should take the lead in initiating discussions and joint studies with other agencies about the applications of telematics to their missions, where the responsibilities of the other agencies have secondary environmental implications. Examples are:

- Department of Interior: resource management, off-shore drilling, etc.;
- Department of Agriculture: farming and forest, crop and grassland management;
- Department of Commerce: weather prediction and warning of natural disasters;
- National Bureau of Standards: building standards and indoor environments;
- Department of Energy: pollutants from energy conversion;
- Department of Transportation: traffic control and emissions;
- National Institutes of Health: environmental diseases;
- Occupational Safety and Health: telematics workers, human factors;
- Federal Emergency Management Agency: disasters and vulnerabilities;
- Office of Science and Technology Policy: a national commission;
- Department of Housing and Urban Development: home and office design and public policies for telematics use.

The Broader Federal Responses To Which EPA Could Make A Strong Contribution:

1. A National Commission on Telematics Policy under Presidential or Congressional sponsorship should undertake to define the long-term national policy choices toward telematics.

2. A number of large-scale, real world intervention experiments should be planned and undertaken under multi-agency auspices with effective but not dominant participation by EPA. These experiments would help to determine the causes, behavior, and consequences of telematics. This information could guide public and private policy choices.

3. An inter-agency coordinating committee under the sponsorship of the Department of Commerce or NTIA or OSTP in the area of telematics would be a useful intermediate step toward clarifying policy choices and coordinating research and study activities.

The overall thrust of these recommendations is that EPA begin defining for itself a responsibility and task with respect to telematics, which is well within its existing Congressional and Presidential mandate to protect the nation's environment, and which, without EPA initiative, will not be undertaken. In that case, potential benefits to the environment and to public health and safety may be delayed or lost, or unnecessary societal costs may be imposed. These recommended actions, if taken, would also begin to identify the latent constituency for EPA telematics assessments.

AFTERWORD

In spite of the breadth of treatment of this study, there are major areas of impacts of telematics beyond the scope of this report. Effects on the health and safety of the labor force were considered, but the more general effects on labor, employment, and job characteristics were not. The even larger question of effects on corporate and business America, international trade and relations, and government are also outside the scope of this report.

SECTION 2

ASSESSING TELEMATICS TECHNOLOGY

Section 2 is a general overview of this assessment, its assumptions, objectives, scope, and boundaries. Basic concepts and terms used in the report are defined.

INTRODUCTION

Two areas of scientific and technological development today hold promise of social benefits comparable to the invention of movable type, the internal combustion engine, and the harnessing of electricity. These two areas are genetic engineering and telecommunications. This assessment deals with the impending revolutionary consequences of telecommunications technology in the next 25 years.

In this report, we use the term "telematics" to mean the convergence of computer, information, and telecommunications technologies. Telematic is, of course, related to the French term "telematique" used by S. Nora and A. Minc in their policy study for the French government ("The Computerization of Society," 1980). As used in this report, the term "telematics" carries no political or ideological connotations. It is a convenient expression for three merging lines of technological developments.

The objective of this exploratory assessment is to identify the potential consequences of telematics development for the physical and natural environment, public health and safety, and our technoeconomy which may have derivative impacts on the environment. This objective, in relation to EPA responsibilities and those of OSASS, has already been stated in more detail in the preface. Briefly, this report summarizes the present state of knowledge and informed expectations about telematics, discusses areas where information is needed for a more thorough assessment, and identifies where basic and applied research is needed to address environmental matters related to those technologies.

The assessment's primary concern is environmental impacts, but it is not, and could not be, limited to environmental impacts. The likely consequences of telecommunications in the future are so broad, complex, and diffuse that many of the social and economic effects could, in turn, hold implications for environmental quality and human health and safety.

The assessment concludes that on balance the effects of telematics on environmental quality should be strongly positive—that is, beneficial. The capabilities which telematics can provide for monitoring environmental

EPA-287 (Cin.)
(4-76)

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quality, for detecting and tracing pollutants, and controlling them at the source, and for diagnosis and treatment of disease and injury, including those of environmental origin, will be invaluable.

There are some possibly significant environmental problems associated with increasing use of telematics. The most important of these concerns, which are just emerging into public awareness, are the possible adverse effects of microwave radiation. At present, scientific knowledge is not sufficient to determine reliably the scope or seriousness of the hazards and risks from electromagnetic radiation. More research is needed in several areas which probably fall within EPA responsibility.

There can be little doubt that telematics, in the future, will bring about significant technoeconomic changes. The continuing growth of electronic industries, their integration with communications industries, a new wave of industrial automation (including industrial robots and related technologies), and, most importantly, the uncertain and controversial effects on the location of people and industry will surely have long-range implications for environmental change, protection, and management. This report suggests what some of the secondary environmental impacts may be and identifies trends which should be monitored as part of EPA long-range research planning. It concludes that in population decentralization, telematics is a facilitator rather than a driving force, and that while decentralization would relieve some current environmental problems, it could make others more difficult to monitor and control.

Most of the potential benefits of telematics will be captured through the workings of the market without government intervention. However, efforts by EPA and other agencies acting cooperatively with industry and public interest groups could stimulate innovation and encourage timely applications of telematics for the meeting of public sector needs and national objectives.

In the long run, it is in the interests of all parties, including the telematics industries, to anticipate, prevent, relieve, or solve any environmental, health, and safety problems that may emerge from telematics. In the short run, however, the major actors in telematics development, including Federal mission agencies, do not have any incentive or mandate to search out such problems so that they can be dealt with at early stages of development. The primary stakeholders have few or no incentives for identifying environmental problems before they become undeniably bad problems. This alone justifies, if not demands, that EPA planners carry out broad, exploratory, assessments as an early warning system on real problems and as a means to allay any public alarm that is not warranted.

THE PACE OF TELEMATICS DEVELOPMENT

Telematics applications can either substitute for or supplement a broad range of basic technologies and productive activities and at the same time add capabilities which do not now exist. Nothing short of a "doomsday scenario" would prevent the increasing adoption and use of telematics in the long run. However, the pace of adoption will be affected by a great many factors and

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will be more rapid in some sectors of the economy and the society than in others. Factors which will influence the pace of telematics development and adoption are discussed in Section 4, The Societal Context of Telematics. Our analysis concludes that these perturbations will have few lasting effects on the overall social impacts of telematics. If insufficient capital or market resistance blocks the widespread acceptance of one telematics technology, there are alternatives. The major impacts on society, which will mature around 1990-2010, will come from exploitation of new capabilities offered by telematics which are common to several subsets of technologies, as will be discussed in Section 3.

Revolutions driven by technology do not come about overnight. Change will be driven by a steady, rolling accumulation of small modifications resulting in a body of irreversible differences in the way we organize our personal and collective affairs. Technologies will be introduced in different forms and for different purposes, as substitutes to improve old processes or to perform new functions. The cumulative effect will be to remake our world.

While telematics, especially telecommunications, is not a new technology, the pace of change and integration is quickening. We are learning to combine many communications media and technologies which had been separate into large, sensitive, flexible systems. To complicate matters, there are a number of social and economic trends interacting with the telematics revolution to produce unexpected events. Fortunately, we live in an era when, for the first time in history, we have the perspicacity to recognize that we are in the midst of a revolution, and an opportunity to anticipate and to mold our future. While the forces are in motion, the technology is changing, substitutions are occurring, and a new web of technological dependency is being spun all around us. The major effects are 15 to 30 years in the future. That is only a short time, yet it is enough for us to understand, to discuss, and to act intelligently on our collective behalf.

Unlike many other technologies, telematics has been received as an almost unblemished blessing. But there are some strains of concern among the general public—notably over matters of privacy and security of information systems, long-range effects on employment, and the effects of television on our youth. There is a small and, to a substantial degree, neglected scholarly literature on the long-term implications of the information revolution, the so-called post-industrial society, the technotronic age.

By and large, however, there has been little systematic attention to long-term environmental implications of this new era. Even the biological effects of microwave radiation—such as presented in the purple prose of The Zapping of America /1—has failed to excite a broad base of concern. It is not surprising, therefore, that the more distant, latent, and subtle—but perhaps more important—consequences are largely unexamined.

The Environmental Protection Agency (EPA) is concerned about the quality of our natural environment, human health, and societal well-being. It is in the interest of EPA to be aware of any possible dangers from telematic devices and, equally important, to understand how other trends may interact with telematics to intensify or mitigate its possible effects.

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EPA-287 (Cin.)
(4-76)

THE SEARCH FOR IMPACTS

It is fairly straightforward to anticipate some highly credible consequences of telematics technology. Many have speculated, for example, that telecommunications may substitute for transportation and thereby improve the environment by reducing the use of automobiles. Air pollution and the raw material and waste disposal side of our industrial cycles could be affected. As we substitute information technology for other kinds of basic labor, workplaces may become cleaner and safer. As telecommunications networks permeate society, we may be more readily able to respond to medical emergencies, fires, accidents, and natural disasters, and to improve the health and well-being of our citizens.

The random generation of significant implications of technology is one route to understanding the future, but it is not a sufficient basis for coming to grips with a potentially limitless number of changes. We need a strategy for search and sort. The strategy adopted in this paper is to take lessons from what we know about the major and minor effects of other technologies and to use those generalizations as search rules for probing the future. The dominant effects of technologies come about in the following general ways:

- Technology itself will produce effects. The individual elements of telematics technology must be manufactured. They require raw materials; they must be shipped, stored, used, and disposed of. Hence, the devices themselves have environmental implications.

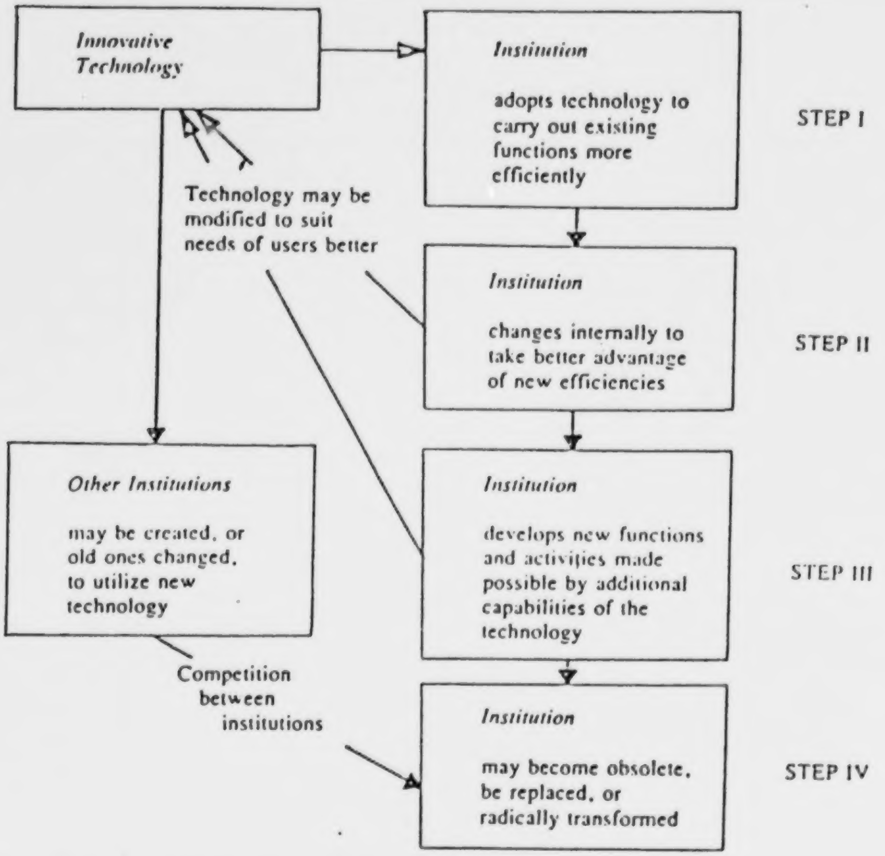
- The individual elements of the technology join to form systems. Those systems can be quite local or may involve a nationwide electronic funds transfer system or a nationwide data credit system. Systems may also involve the Strategic Air Command or a communications satellite linking the United States to any other spot in the world. A system has its own implications for the environment in terms of its initiation, planning, construction, operation, maintenance, and final decline and disposal.

- New technologies may substitute for older technologies. Insofar as telecommunications substitutes for transportation, it will have effects on what is removed from the market and from society in addition to the effects of its own intrusion.

- The capabilities to do new things or to do old things better are implicit in every new technology. Those capabilities can have environmental effects. For example, the laying of the Atlantic cable provided the capability of instant communication which drastically changed the commodities market and the financial structure associated with basic materials and manufactured goods in trade and commerce.

- Trends outside the area of telecommunications will interact with telecommunications in ways that cannot be discerned solely from the technology itself. Telecommunications technology examined in a social context determines what effects will be more or less important. As family size grew and declined, America suburbanized and may now be

EXHIBIT 2-1: IMPACT OF TECHNOLOGY INNOVATION ON USER INSTITUTIONS


Innovative Technology
Institution
adopts technology to carry out existing functions more efficiently
STEP I
Technology may be modified to suit needs of users better
Institution
changes internally to take better advantage of new efficiencies
STEP II
Other Institutions
may be created, or old ones changed, to utilize new technology
Institution
develops new functions and activities made possible by additional capabilities of the technology
STEP III
Competition between institutions
Institution
may become obsolete, be replaced, or radically transformed
STEP IV

Source: Impact of technology innovation on user institutions' (after Joseph Coates, Telecommunications Policy 1:196-206, 1977).

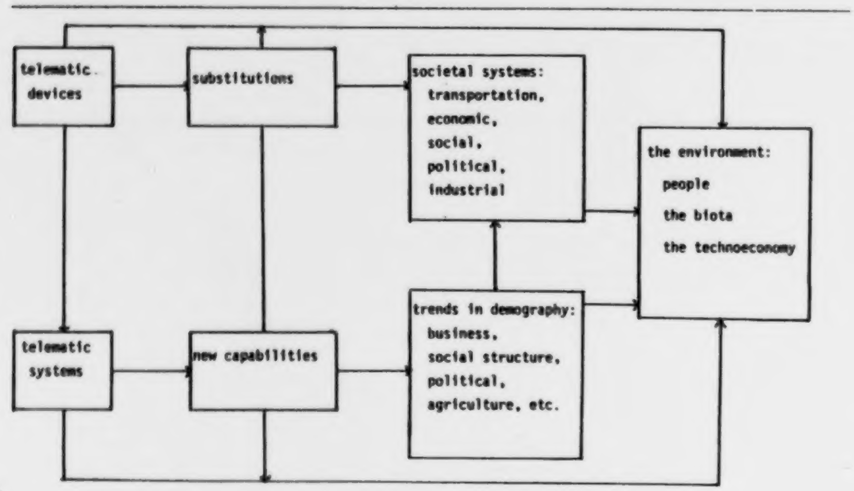
reurbanizing.

These sources of impacts are shown in Exhibit 2-1.

Let us now turn to a brief expansion of some of the elements in a strategic approach to understanding telecommunications futures. Exhibit 2-2 displays some of these direct and mediating interactions.

The profound impacts of a technology are often not the immediate ones, when the new thing is used to do an old job better, or even the secondary ones, when the old system changes to take better advantage of the new thing. The big effects are usually the third order and later impacts, when new activities are generated as a result of the new technology's capabilities. For example, computers originally adopted for payroll preparation allow a merchant to move to continual inventory control.

EXHIBIT 2-2: HOW TELEMATIC SYSTEMS MAY IMPACT THE ENVIRONMENT


telematic devices
substitutions
societal systems: transportation, economic, social, political, industrial
the environment: people the biota the technoeconomy
trends in demography: business, social structure, political, agriculture, etc.
telematic systems
new capabilities

Turning to telecommunications technology, we can illustrate both the technology and technology systems with the simple prototypical example shown in Exhibit 2-3. This exhibit lists the elements of the telephone system and roughly shows how those elements come together to make more complex and more socially significant societal systems. A brief review of Exhibit 2-3 illustrates:

> The basic equipment—the instruments, the wires, and the laying of the wires—have environmental effects in terms of requiring raw material such as copper and petrochemicals. They require tunnels, poles, and underground wiring conduits, and have an effect on both the aesthetics and the texture of the countryside and the city. Telephone companies employ people at central stations and out on the road; these people move to and from work. Telephone books are a central part of the telephone system; they require paper, printing, and distribution, and generate urban and rural waste. The laws and regulations bounding the system determine choices as to when we can use the telephone, what we can use it for, and what we cannot use it for.

This rough sketch of the environmental impacts of one telematics technology should suggest the pregnant implications of expanding the probe in two directions—depth of treatment and diversity of technologies considered.

EXHIBIT 2-3: ELEMENTS OF A TELECOMMUNICATIONS SYSTEM

Element	Example From Telephone System
Equipment (hardware)	telephone instruments wires to connect instruments switching devices to route calls equipment for producing the above
Organizations of people who operate the system	telephone operating companies and their employees telephone equipment manufacturers and their employees
Instructions and procedures for for use (software)	telephone books dialing rules and procedures
Users	telephone subscribers pay telephone users
Rules for access to system	rate structures procedures for gaining residential or business service
Rules by which society controls the system	relevant laws and regulations
People who are assigned by society to operate the control process	Federal Communications Commission judicial system

Long-range social trends which will condition both the pace of future telematics development and its impacts will be discussed in depth in Section 4. They are especially important in relating telecommunications to centralization and decentralization. Three major interacting forces merit special consideration. The increased cost of energy is the sharpest, most certain new force changing the structure and organization of the economy. The second major force is the changing nature of work and employment. These two forces seem to be working in opposite directions. Energy inflation is centripetal, drawing people closer together into more densely packed units and areas. On the other hand, telecommunications may be a centrifugal force, permitting people to locate further apart in more independent, physically discrete units. Demographic change as a third major force involves a large number of variables moving in many different directions, promoting both centrifugal and centripetal changes.

EPA-287 (Cin.)
(4-76)

ASSUMPTIONS AND DEFINITIONS

This report is primarily addressed to EPA decision-makers. But it is also written in anticipation of a larger audience of people who have an interest in decisions which the government may make which affect the development and use of telecommunication technologies. It speaks first to the Environmental Protection Agency, but also to the rest of the Federal government because telecommunications technologies serve the whole of government. The potential audience outside the Federal government includes everyone in the U.S. and in many other places, but especially the makers of telematics devices, individual and institutional users of telematics technologies, industries and institutions which may change significantly as telematics technologies become more pervasive.

This report is exploratory, synthesizing, and interpretive. It discusses how the convergence of the technologies of telecommunications, computation, and information is likely to interact with ongoing social, economic, and political trends, and how the result may impact the biota, human health and safety, and the technoeconomy. The reader will find relatively little new data, few detailed technical descriptions, and no quantitative predictions.

Some basic definitions are needed.

The environment is used to refer to the scope of EPA's interest, as stated in their request for proposals to perform this work, which is the biota, human health and safety, and the technoeconomy.

The biota include the earth, its plants,its animals, its soil, air, and water as media for living things except for those parts which are included in the other two categories.

The technoeconomy refers to the artifacts, laws, and physical and organizational processes of human culture. Thus, we will consider commercially raised plants and animals as part of the technoeconomy rather than the biota. However, public parklands, endangered species, grasslands, and forests are here considered part of the biota.

A technology is a goal-directed social, physical, or biological application of arts or science. It includes machines, games, medicines, the written word, and many other human creations.

Telematics is a group of technologies which include all parts of systems which merge computer, telecommunication, and information technologies. Most such systems employ all three, although use of any two will qualify.

This report should assist OSASS/EPA to identify research which should be conducted to support the agency's mission over the longer term future. In addition, it will help to inform the development of domestic and international U.S. information policy, and contribute to the general understanding of the impact of telematic technologies.

Hence, the first goal of this assessment is to describe the environmental impacts of developing telecommunications technologies; the second goal is to separate those impacts over which we can have some influence from those whose causes would be beyond control. The third is to identify what we still need to know, and to highlight those areas in which research and planning are not underway.

The study team undertook the following steps:

- to provide a conceptual framework useful for analyzing the impacts of telecommunications technologies and for protecting new technologies;
- to identify the range of technologies which may operate in the relatively distant future of 2005 to 2010;
- to generate the widest possible set of impacts which they could have on human health, the environment, and human culture;
- to consider the social, political, and economic environment within which the technologies can be expected to develop, including trends, critical events, and types and groups of people who can be expected to gain, lose, and wield power under different conditions;
- to devise criteria with which to sort the impacts according to relative seriousness;
- to identify knowledge gaps which now prevent us from knowing about potential hazards resulting from telecommunications technologies and the conditions under which they might come to pass;
- to identify work which is now in progress which may fill those knowledge gaps.

WHAT FOLLOWS

The next section, 3, is a brief introduction to the technology of telematics. It describes the elements of telematics technology, some telematics systems, and some social and societal systems using or dependent upon that technology.

Section 4 deals with trends—both within the domain of telematics and within the larger society—which will interact with, affect, and be affected by, telematics.

The next section, 5, treats the interaction of systems, trends, and general impacts, to define significant environmental impacts with regard to human health, the biota, and the general technoeconomic enterprises of our society. Section 5 also discusses criteria for evaluating impacts in the light of EPA research and planning.

EPA-287 (Cin.)
(4-76)

Section 6 supplies the policy context within which EPA should consider research on telematics. It identifies the principal parties at interest and describes the dynamics of their interaction.

Our findings, with special attention to knowledge gaps, are discussed in Section 7. From those knowledge gaps, useful research goals are proposed on two important questions: (1) basic knowledge required to better understand the interaction of telecommunications and the environment, and (2) better knowledge specifically required to inform public policy.

Finally, in Section 8, we discuss research which is already in progress and make specific recommendations to OSASS/EPA regarding the sponsorship of research in telematics.

There are, as well, two appendices. The first is an annotated bibliography of important literature in the field. The other discusses methods used in this assessment.

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SECTION 3

TELEMATICS:
TELECOMMUNICATIONS, COMPUTER, AND INFORMATION TECHNOLOGIES IN COLLISION, CONVERGENCE, AND COALESCENCE

This chapter is an introductory overview of telematics technologies and telematic systems. It discusses five domains of technology and their emerging integration. Understanding the technology is crucial to understanding the new and unprecedented capabilities of telematics. The generic characteristics of these new capabilities will be a primary stimulant of change in social behavior and the structure and function of institutions.

The reader who is well-informed about these technologies may wish to skip all but the final section of this section on "The Social Characteristics of New Capabilities."

INTRODUCTION

Public processes of discussion, planning, action, management and evaluation must be based on some recognized definitions and shared concepts and beliefs. The function of this section is to present a simple framework for ordered speculation about telecommunications and computer technologies which are now already in use or are on the verge of practical importance.

The five domains of telematics are:

- computers, calculators, and kindred devices,
- telephony and telegraphy,
- audio and video broadcasting,
- those devices which come out of still and motion photography and graphics, and
- information technologies.

The technical, historical, institutional, legal, and corporate bases of these main domains of technology are quite different. These domains are rapidly coalescing, interacting, converging, and competing to form new structural systems and capabilities. These clusters of technologies began in different historical periods and evolved in economically different institutions. They

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EPA-287 (Cin.)
(4-76)

have enjoyed quite distinctly different legal status and relatively different degrees of public and private control. It is in order to sidestep this confusion that we adopted and adapted the French term telematique—telematics—which treats all of these technologies under a new rubric. From a more technical point of view, we take telematics to be the use of electrons, light, and electromagnetic radiation for communication, control, memory, and related purposes.

This section is elementary in both senses of that word. It presents basic information about the telematic devices and systems in simple, and as much as possible, in non-technical terms. The order of presentation will first discuss familiar devices well embedded in our current history. We then move to more recent devices, and finally to those coming into prominence. Having described the elements, the discussion moves to technological systems and software developments coming out of the interplay of the devices. There is a brief discussion of ancillary devices, some of which are not usually included within the telecommunications/computer lexicon. With those pieces in place, the discussion then moves to larger scale telecommunications systems and related societal systems.

WHAT TELEMATICS DOES

Before taking a look at the technology and its systems, it may be useful to review some of the functions telematics perform and some general factors in that performance. The most obvious and the original burden of telecommunications is to transmit messages. Originally these were in the form of text (telegraph) and voice (telephone). More recently, we have learned to transmit images of all sorts, including color and three-dimensional graphs. Combinations of these techniques—for example, videophone, teletext, and long-distance xerography—allows people to approximate a face-to-face business meeting.

Some messages are composed simply of bits of data. If people have previously decided the way the data will be structured, it can simply be packed up and transmitted in an agreed-upon format without the accompaniment of other interpersonal communications. Other messages refer to interchangeable objects, and telecommunications does, in effect, allow their transfer. What began with wiring money by telegraph has become electronic funds transfer (EFT), by which much of the world's banking can be accomplished without currency ever physically changing hands. Now, ownership of anything that need not or cannot be physically transported can be exchanged in this way—from shares of stock to land deeds. Telematics is carrying the economy to a fourth level of symbolism—gold to paper, to checks, to magnetic storage. Authority may also be transmitted by telecommunications, whether that authority is political, military, institutional, financial, or moral.

Telecommunications systems may be of a form to allow one-to-one communication in either one or both directions. The common pager which beeps and telephone exemplify each pattern. They may also have a unidirectional one-to-many broadcast form, as with traditional radio and television. Television security systems reverse this pattern with unidirectional many-to-one transmissions. Some technologies allow a bidirectional message

EPA-287 (Cin.)
(4-76)

flow among several points. For example, a broadband cable television system may allow subscribers to transmit from their homes or businesses and target on specific groups of other subscribers. Often systems will combine technologies to achieve the communication patterns they need with lower cost. For example, a cable television system need not always have video transmission capability for its subscribers when a many-to-many pattern is needed. Often it is enough to combine cable in one direction with telephone response in the other. Changes in the communication pattern which a given technology permits often have major social impacts.

The flexibility to control the amount of time between recording and transmission of messages and between their reception and play-out is important. With television it is useful sometimes to have live broadcasts of important events and at other times to have the freedom to edit and rework material before its transmission. The development of telephones which can receive and record messages while their owners are not present or to forward calls to another number extends their use. Similarly, the ability to use computers in real time, combined with developments in microprocessor technology allowed the development of text editing and memory typewriters.

It is well known that in general the cost of telecommunications has decreased as the technology has developed. There may be several break points which separate socially significant cost ranges. For instance, a cost low enough that the average small town could afford the system would mark one step; a cost which is affordable for most families would mark another; a cost which makes the system a nearly universal personal possession would mark an extreme.

There are five basic internal functions of telematic systems which are clues to future consequences. These are:

- format a message,
- transmit a message or authority,
- record a message,
- store a message,
- manipulate messages through computation, switching, or problem solving techniques.

Most telematic systems do not perform all of these functions.

Virtually all telematics media encode messages at one point or another. Messages may be encoded directly into electromagnetic waves, or encoded first in digital patterns and then into electromagnetic waves. The difference is significant because a digital message may be recorded and stores far more easily. Moreover, with digital coding, telephones and television may be integrated with computers in versatile and powerful systems.

Channel capacity refers to the volume of messages which a given medium will accommodate. Again, taking the telephone as an example, the

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old-fashioned, basic telephone used one twisted pair of wires per message at a time, so that a given call had exclusive use of whole wire for its duration. With multiplexing equipment and digital coding, more than one conversation can be carried on a wire at a time. This represents a great increase in channel capacity. With the adoption of fiber optic filaments instead of traditional wires, the capacity is increased further. Optical fibers use lasers to conduct impulses on a broader bandwidth so more conversations can be carried on one line at the same time. In addition, they are thinner, so that more lines can be stuffed into a cable of a given diameter. There have been similar increases in channel capacity in other telecommunications media as well, and there are substantial differences in channel capacity among media.

Let's now turn to the devices that are the bases of these functions.

THE TELEMATICS TINKER-TOY

This section reviews the basic technological devices, the functioning elements, with which present and new systems are designed. Little attention is given to the technological details or the scientific principles on which the devices are based. With the earliest and most unfamiliar devices, we rely on the reader's common knowledge about them, and the common understanding of how they work and what they can do. As we move to newer and less familiar devices, a bit more attention is given to capabilities. Most of these devices are in a strict sense systems. Therefore, treating them as devices, of necessity, falsifies their nature to some extent. On the other hand, we can start at any stage in a hierarchy of technological systems and take that stage as the basic unit about which we are speaking. To illustrate specifically, a xerographic reproducing machine is itself a complex functioning system of elements and connections, and is the product of elaborate technological, research, marketing, and maintenance systems. However, for this report, it is taken as a basic unit. That level of discussion may be most useful to start us off.

The elements of the telematics tinker-toy are in use or in development. For much of the telematics system, the future is now. However, telematics has not yet revolutionized every aspect of our lives. Of the myriad services telematics could perform, only a handful have been realized. The incipient revolution in telematics is in the wedding of the technology, the capability, with services—banking, education, environmental monitoring, medicine, transportation, manufacturing, farming, entertainment. The pace and direction of the telematic future will be determined largely by the forces—especially the market forces operating in these service areas. The following subsections describe the capabilities encompassed in the emerging telematics tinker-toy that will be adopted in varying configurations by different sectors of the economy. We had automobiles in 1880 but they did not work their revolution for fifty to seventy years. Perhaps telematics is now like the auto in 1920.

BASIC DEVICES WIDELY AVAILABLE BEFORE 1960

The most commonplace telecommunications devices known to anyone born since 1930—and familiar if not commonplace in their intellectual and functioning furniture—are shown in Exhibit 3-1.

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PAGE NUMBER
EPA-287 (Cin.)
(4-76)

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EXHIBIT 3-1: TELEMATIC DEVICES WIDELY AVAILABLE BEFORE 1960

- Telegraph
- Telephone
- Microwave transmission
- Radio (AM/FM)
- Television (B/W)
- Facsimile
- Phonograph
- Tape recording
- Xerography
- Cable (one-way)
- Transponders
- Typewriter
- Movies
- Still photography (B/W, color)
- Polaroid
- Microfilm
- Robots - first generation
- Mainframe computers

6-1/2"

The telephone and the telegraph provide place-to-place communications, AM and FM radio expand communication from one-to-one to one-to-many. Radio has a higher information density, but does not provide easily and cheaply for two-way communication or ready feedback. Black and white TV enhances, supplements, and, in part, replaces speech with images. Facsimile provides image without speech. The phonograph and the tape recorder provide a cheap and convenient way to reproduce the spoken word, music and other sounds in a widely available stored format for repeated use. The big invention of xerographic reproduction permits both permanent and ephemeral written and typed words, glyphs, and graphics of all sorts to be copied and reproduced at incredibly low cost and at tremendous savings in skilled labor, e.g., stenographers and typists. The introduction of cable systems and transponders opened up TV to those cut off by physical barriers from line-of-sight broadcast. The reader should keep in mind that TV and FM radio can be received only through line of sight, not over the horizon. Hence, their need for tall transmission towers.

The typewriter, movies, black and white photography, and polaroid are all commonplace and familiar. Microfilm permits the printed word to be cheaply reproduced, packed, stored, mailed, and handled. The big development before the 60s—new and exciting in all regards—was the large scale, or mainframe, computer. It and the associated memory devices began the computational revolution. Finally, first generation robots (or as it was called then—automation) came into use. The first generation machines are capable of repeatedly performing complex, multiple, fixed functions. They called for large capital investments and were used over and over again, i.e., as in drilling out engine blocks on the automobile assembly line.

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EPA-287 (Cin.)
(4-76)

EXHIBIT 3-2: TELEMATIC DEVICES WIDELY AVAILABLE BY THE EARLY 70s

- Touchtone pad (push button keyboard)
- Call forwarding
- CB radio
- Picturephone
- Portapak video recorder, the minicam
- Color television
- Portable television
- Frame grabber
- Slow scan
- Private microwave transmission
- Audio cassette
- Low cost xerography
- Two-way cable television
- Electric typewriter
- Geophysical satellites
- Optical scanner
- Microfiche
- Robot - second generation
- Hand calculator
- Minicomputer
- Central processing unit memory

DEVICES AVAILABLE IN THE EARLY 1970s

By the early 70s, many of the new telematic inventions of the post-war period came to maturity and began to have significant effects. Exhibit 3-2 lists these principal devices.

- The touchtone pad—that is, the push button keyboard on the telephone—is a key element in potentially making every telephone a computer link. Recall how your bank teller can now check your account by punching up on the computer, your account number, and the coded request for information, using the telephone buttons.

- The picture telephone, available in principle for two decades, received some early and unimpressive trials. Today it is institutionalized and functioning in several big cities and in private facilities. Picture telephones make available a point-to-point, two-way, audio-visual capability.

- The portable video recorder (portapak or minicam) opens up the potential of anyone going anywhere on a low budget to make his or her own films. We tend to think of television as a passive, viewer technology. Yet, now the technology is available which permits any child or adult, for $1,000-$1,500, to go into the world and make talking films. The opportunity to do this will impact on education, open up new art forms, and expand our modes of understanding. The capability to select, recast, and interpret the world in a visual medium could raise our levels of attentiveness and sensitivity to unprecedented subtlety. The world will be seen differently by those who make their own films. The portapak is to television and movies what the Brownie box camera was to 19th century studio photography.

- Television sets themselves became portable and available in color at extremely low cost. TV was technically augmented by devices such as slow scan and the frame grabber to permit one to examine at any desired pace the material on the screen or to take a particular frame, that is, a particular picture, and freeze it on the screen.

- Microwave technology was available for transmission in the 50s, but only over public channels. In 1959 private operators were allowed to put up microwave transmitters, thereby launching a minor technological revolution.

- Audio cassettes are a big improvement over previous tape recording. They affect the rendition of popular music, story telling, office practices, memoranda writing, and have given business and the lay person the acoustic equivalent of cheap photography.

- Low cost, small copy machines have moved the xerographic revolution many steps ahead.

- In cable it has always been, in principle, possible to communicate in two directions. Increasingly, since 1970 two-way has been a functioning reality in which it is possible to communicate not only from, but to, the head end, that is, to the station. Cable also has begun to acquire independent status as a new high quality medium for presenting television material. Cable TV, on a much larger scale than other technologies, will weave the nation together. It was originally developed as a way to bring improved television broadcasts to out-of-the way communities, to homes beyond the hills which were shadowed from traditional broadcasts. It has now become a technology on the brink of commercial dominance. Cable television brings high quality viewing to the home. Instead of four, five, or six channels, it brings the capability of 30 to 80 channels. The first net effect of cable television on American society will be to break the dull and deadening monopoly of the big broadcasters; the day of centralized television out of New York or Los Angeles is about to pass. Diversity is the order for the future. Every agency, group, institution, organization, and individual will have a reasonable chance for access to the medium. A true intellectual and artistic free market may yet operate. The implication for education is clear in that truly educational channels in great abundance will be available. However, the problem is not their availability, but in filling them with useful, worthwhile material.

- The electric typewriter came into its own in the 70s and is now a major interlocutory device with computers, punched tape, electronic devices, home consoles, etc.

EPA-287 (Cin.)
(4-76)

- Optical scanning devices to examine and interpret all kinds of printed and non-printed material moved into the realm of practicality.

- Communication and observation satellites became institutionalized. Space communication satellites, made legally possible in 1962, became practical by the 1970s.

- Big improvements involving central processing memories further increased the capacity of mainframe computers. By the early 70s, the minicomputer and the hand calculator were coming onto the scene in a big way. The hand calculator puts in the hands of students and citizens at large a capability roughly equivalent to the most sophisticated pre-electronic devices—at prices of $5-$35. The extent of the use of the hand calculator is such that some 80 million may be in use in 1980, with a steady market of replacement and upgrading of 20 million per year.

- Microfiche began replacing microfilm to give new degrees of convenience at very low cost.

- Second generation robots came on to the market. These reprogramming robots were capable of performing a particular function and having that function changed or modified in quite drastic ways to go on to perform new and different functions.

NEW AND EMERGING DEVICES AROUND THE 1980s

Devices now coming into ascendency, in addition to those previously described, are listed in Exhibit 3-3. The new items have not led to displacement but to integration of old and new devices in all sorts of ways.

- The premier device in ascendency in the 80s is the microprocessor—the so-called brain on a chip. This device effectively reduces to small, low cost, manageable size the computational and other computer capabilities previously available only in large facilities. Large-scale integrated circuitry has made the microcomputer and the minicomputer functioning realities. The microprocessor, as its costs have declined, now holds the potential of being applied to literally any human artifact which involves memory, control, feedback, recognition. It is itself spawning devices right and left. The tiny, silicon chips that carry integrated circuitry contain all the logic of a small computer. They may operate independently or be wired to a larger computer as part of a complex operation. They permit the remote, electronic control of all sorts of machines—from household appliances, to automobiles, to industrial equipment. For example:

    — Cars can continuously monitor and adjust their own timing, ignition, and carburetor mixture, and calculate and display fuel efficiency to the driver;

EPA-287 (Cin.)
(4-76)

EXHIBIT 3-3: TELEMATICS DEVICES NOW AND EMERGING IN THE 80s

- Microprocessor
- 800 numbers
- Voice answer-back
- Voice activation
- Low cost video recorders
- Videodisks
- Large screen television
- Laser
- Fiber optics
- Video cassettes
- Electronic scratch pad
- Direct satellite broadcasting
- Word processor
- Graphic and color display
- Speech compressor
- Packet switching
- Robots - third generation
- Microcomputers
- Large scale integrated circuits
- New memory systems: solid state, laser, bubble, backend processes
- Morpheme generator

— Household thermostats can be programmed to maintain a variety of temperatures according to time of day, weather conditions, or other factors in the house as a whole or on a room-by-room basis;

— Cheap toys can be produced that will interact with children by means of sound or visual displays;

— Medical devices, like tiny pacemakers, can be implanted to monitor or to help control vital body functions such as heartbeat, thyroid activity, ovulation, and fetal development.

According to Professor Licklider of MIT, since the mid-60s the capability of the chip has gone up over 10,000 fold, and is still increasing while the cost of the chip has remained fairly constant at $5-$50. As a rule of thumb, every new development in micro-chip technology comes on the market at $50 and in two or three years is selling for $5-$10.

- With regard to the telephone, the development of the 800 numbers creates a nationwide capability to search, sell, and scan. Additionally, voice answer-back automation devices permit flexibility in response to touchtone signals. Voice activation gives a new degree of flexibility to many kinds of equipment. While voice activation is well established, voice recognition is still being developed.

EPA-287 (Cin.)
(4-76)

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- Low cost video recorders now give the capability to selectively record from commercial as well as private video pickup. This will enable us to build personal, commercial, and public video libraries. It gives flexibility to visual recording which is comparable to the flexibility that platters and tape have given to sound recordings.

- The videodisk, looking superficially like a phonograph record, captures all the information equivalent to a 30-minute television broadcast. It captures the equivalent of 54,000 snapshots—frames, in the jargon of the trade—on a single disk. It permits all the audio, that is, all the sound message, that would normally accompany those frames. The capability to package this vast amount of information, in the equivalent of a small piece of luggage, will change scores of information demanding activities. For example, someone doing a complicated, sophisticated repair job—let's say, on the innards of a military tank—may be able to climb into the tank with his videodisk set up, get a display of what he is to look at, punch a button to indicate where the problem is, and have called up to him not just a written message, but a spoken and written message describing what he should do next, what he should look for, etc. The capability to pack 100 linear feet of repair manuals into a suitcase and have at the fingertip both visual and aural inputs (which incidentally are self-searching, not at all like paging through a manual) could enormously accelerate the capacity to deal with complex information. The videodisk—by combining printed, spoken, and graphic materials in one small package—will have a profound impact on the training elements of education and could very well have a revolutionary impact on the grasping of concepts and complex interactions and events. The videodisk may completely change vocations, vocational education, laboratory training, home and automotive maintenance and repairs, and scores of other things requiring integrated grasps of complex technologies.

- The large screen TV now makes it possible to use theatre seating and adds great flexibility to the use of TV communications.

- Video cassettes are on the market.

- The electronic scratch pad permits communication back and forth, in real time, of graphics, notes, and messages generated ad hoc, and gives an unprecedented degree of personal flexibility to communications. Imagine two people a thousand miles apart drawing and modifying a diagram together.

- Graphic and color display is now commonplace.

- The word processor is working its well-known revolution in office work. It offers the prospect of every author being his own publisher.

- Perhaps equally important, but less widely known, is the generation of a practical voice synthesizer—morpheme generator. The fundamental unit of human speech in the phoneme—the sounds of single letters.

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PAGE NUMBER
EPA-287 (Cin.)
(4-76)

These combine to form morphemes which are the building blocks of speech. An exciting technological breakthrough based on the microprocessor generates a passable version of the human voice without using prerecorded messages. On instruction it will sound out any message within its programmed capabilities. The device is now available in an educational toy called "Speak and Spell":

  - The child spells by punching buttons for each letter, H-O-S-E. A visual read-out shows what he has punched in, and a voice sounds back, "I'm sorry, that's incorrect, please try again." The child spells it again, H-O-U-S-E; "Thank you, will you now spell candy."

This electronic device now makes it practical for any machine or device to talk to its operator. The implications for this for the handicapped, for the foreign language speaker, and for the semi-literate are enormous. It opens up the world of information to those who are intrinsically, accidentally, or by culture limited in literacy. The morpheme generator will speed up understanding, skill building, and access even for the most literate who are moving into the unfamiliar.

- Although satellites have been with us for many years, recent developments will allow much wider use. There are now many more communication satellites and they are far more powerful. Signal receiving dishes have dropped in size and price to the point that they are within the grasp of most American communities and businesses, and many families. We are now able to send many more long distance messages with far better quality signals and to receive them directly in our homes and businesses. Packet switching is the great exciting development in the use of communications satellites. With satellite communications:

  - Remote and otherwise isolated communities can gain access to commercial broadcasts, educational television, radio transmission, and other forms of telecommunications;

  - Financial institutions and corporations can set up their own satellite receivers to get news and financial information directly, and to transmit their own data with security;

  - Most communities can get a wider variety of programming with stronger signals.

- Coupled with cable television, satellite communication will permit the ready exchange of information from one local cable TV network to another. All the information of any country in the world will be available throughout the rest of the world—from Katmandu to Capetown, from Anchorage to Andalusia. Libraries will no longer be limited to books; the full recorded knowledge of all mankind will be useful to scientists, scholars, entertainers, educators, businessmen, and recreationists.

- The speech compressor, as an adjunct to voice recordings, for the first time makes the ear an effective information channel competitor with the eye in picking up cognitive materials. In Western culture the printed word is virtually coincident with education. The spoken word, except for the classroom, has lagged far behind in its information transfer capability. While we can conveniently listen to words at the rate of 120-160 words per minute, most literate adults can read 250-400 words per minute. New telecommunications technology now makes it possible to put the spoken word in direct competition with the printed word on an information-density basis. The concept is as follows:

> Imagine the recorded message to be like a salami. Imagine slicing that salami into thousands of thin slices. Then throw away every tenth, or every fourth, or every fifth slice. By pushing the remaining slices back together electronically, one has contracted the message—made it briefer by 10%, or 25%, or 20%. Unlike speeding up a record—which has that unpleasant Donald Duck effect of shifting the voice to a higher pitch—the new voice compressor speeds up the message without any changes in tone. Results suggest that spoken messages up to the rate of 300 to 400 words per minute are fully understandable.

  This new capability opens rapid learning to the visually limited. To all of us it may be the new avenue of learning—while traveling, or jogging, or while engaged in other activities that preclude reading.

- Third generation robots with sensing capabilities are being added to second generation reprogramming capabilities. Microprocessors and integrated circuitry, together with remote sensing devices such as optical scanners, have permitted the beginnings of a new field of application for robots. We are just beginning to see the development of machines which are able to carry out jobs which are demanding of humans. Robots, for example, are capable of finer and more reliable visual discrimination than most people. As robots become inexpensive, they may replace human labor in many jobs. With robots:

  — repetitive assembly line tasks can be performed more accurately and more cheaply than with human labor;

  — one robot may be reprogrammed to perform a number of different household or industrial tasks as needs change;

  — a robot cannot only determine when a job needs to be done, but it can schedule itself over a number of tasks, perform the work, and report in to a coordinating computer when it finishes or if problems arise.

- The home market and the office market have been cracked wide open by microcomputers. Microcomputers are now becoming as commonplace as color TVs in the early 70s.

- Finally, don't forget memory systems. On computers of all scale, memory systems involving solid state, bubble, and laser memories are coming into use. New smart memory systems involving what is technically called back-end processing is adding new degrees of flexibility and sophistication to memory storage.

The above is a brief description of the techniques and the technologies, the tinker-toy of the telematics era. Let's turn now to some of the technological systems capabilities available as combinations of these devices.

SOME SIGNIFICANT SYSTEMS AND SOFTWARE DEVELOPMENTS

Exhibit 3-4 lists some of the current functioning systems and software capabilities coming out of the above technologies. Software is the program and the instructions, in any telematic system.

- Computer utilities are analogous to electric utilities—plug in where and when you will. Major utilities such as Illiac IV, ARPANET, and the PLATO system at the University of Illinois are predecessors of the new capabilities for large scale computer communication, information, manipulation, and storage capabilities. Computer conferencing is a widely practiced, although minor, art dependent on computer utilities.

- Paralleling computer utilities are information utilities. Traditional bibliographic searches are available in enormously rich systems such as Lockheed, and commercial systems directed at home and small business users such as The Source. Teletext and videotex are spreading worldwide. They effectively put information of any sort, any size, any scope, any degree of cognitive content in the hands of any user wired into the system. "Teletext" is used here as a generic term for the broadcast of text and graphics as part of a television signal. "Videotex" is suggested by the International Telegraphy and Telephone Consultative Committee (CCITT) as the standard term for the generic class of services that provide transmission on an interactive basis, typically through a telephone connection between a television and a computer. ("Viewdata" is a term that is often used interchangeably with "videotex".) The systems are illustrated in Exhibits 3-5 and 3-6.

- Micro-scale home information systems are capable of tying into the larger information utility, and also are capable of developing their own custom tailored system for personal, business, or corporate information.

- Communications satellites—COMSAT, INTELSAT, ATS-6—are rapidly being complemented by other functioning information satellites, such as

EXHIBIT 3-4: SOME SIGNIFICANT SYSTEMS AND SOFTWARE

- Micro home information system
- Computer utilities
  - Illiac IV
  - ARPANET
  - PLATO
- Communication satellites
  - ERTS
  - weather
  - agriculture
- Other space satellites
  - ERTS
  - weather
  - agriculture
- Computer-assisted design (CAD)
- Computer-assisted manufacture (CAM)
- PBX self-contained telephone exchanges
- Simulation modeling
- Aids to the handicapped
- Electronic switching systems (ESS)
- Mobile cellular system
- Information utilities
  - The Source
  - Lockheed
  - Prestel
- Teletext
- Videotex
- Pattern recognition
  - voice
  - signature
- Encryption

earth resources satellites, weather satellites, and agricultural monitoring satellites.

- The general area of pattern recognition permits the recognition of voice and hand signatures and all other kinds of patterns. That pattern recognition capability is expanding in every conceivable direction.

- Computer-assisted design is working a revolution in the physical artifacts of our world. With computers it is now possible to not only assist in the design of houses, structures, dams, bridges, automobiles, and physical artifacts of every sort, but computers can assist in the design of computers themselves.

- Simulation and modeling, through computer-assisted computational techniques, have brought new levels of understanding of our world—from ecology to nuclear devices, from social behavior to kinesiology. The computer has moved modeling and the use of mathematical tools to a heretofore unimagined level of practicality.

- The PBX (private business exchange) is a self-contained telecommunications exchange framed around microprocessor technology.

EPA-287 (Cin.)
(4-76)

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EXHIBIT 3-5: A BROADCAST TELETEXT SYSTEM*

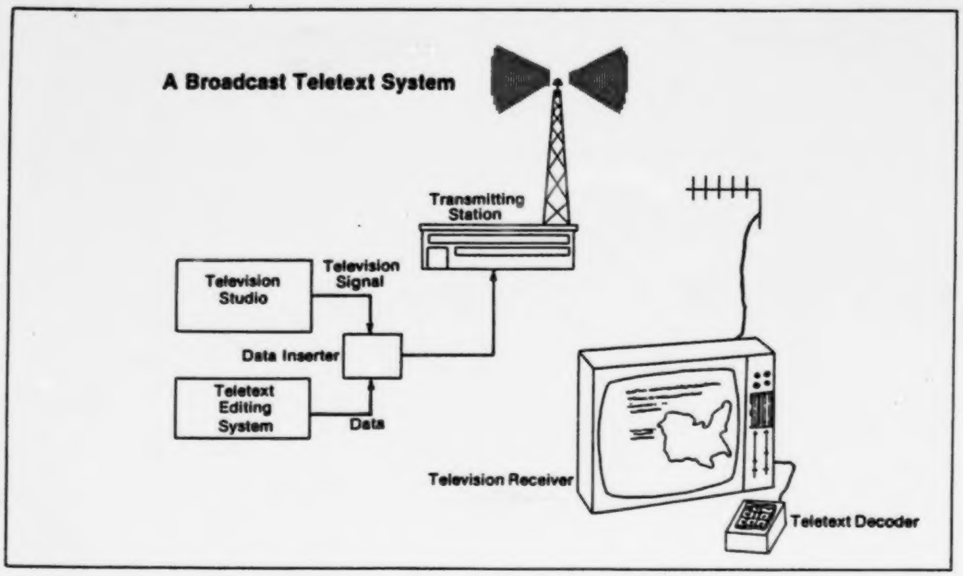
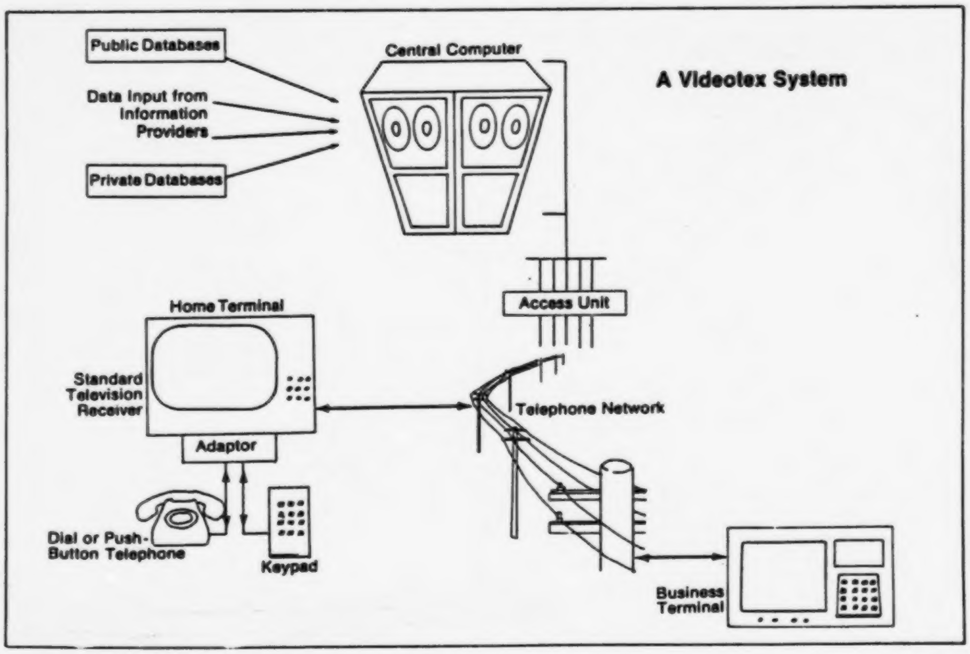

A Broadcast Teletext System
Transmitting Station
Television Studio
Television Signal
Data Inserter
Teletext Editing System
Data
Television Receiver
Teletext Decoder

EXHIBIT 3-6: A VIDEOTEX SYSTEM*


Public Databases
Data Input from Information Providers
Private Databases
Central Computer
A Videotex System
Access Unit
Home Terminal
Standard Television Receiver
Adaptor
Telephone Network
Dial or Push-Button Telephone
Keypad
Business Terminal

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* Institute for the Future Newsletter, Vol. 1, 1979, Menlo Park, California, pp.2 and 5, with permission.

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

It effectively gives any small or large business the full capability of its own internal telephone system.

- Encryption is an increasingly important element of telematics systems. By scrambling a message, encryption keeps unauthorized people from access to information or from altering information. Medical records might be encrypted to prevent unauthorized disclosure. A nuclear power plant's telecommunications might be encrypted to prevent interference. The basic technology of encryption is adding and subtracting messages from random noise—to do this the sender and the receiver use keys to specify how the coding is done and how it can be undone. For example, in "stream ciphering", the sender adds the message to a random sequence; the message is sent to the receiver where the random sequence is subtracted and the message emerges. In the past, encryption has been largely of interest to government agencies—especially in national security. With the growing use of telematics in the private sector, the need for private encryption devices has increased; banks are among the major users of encryption. As businesses move to greater use of telematics, encryption will also increase; SRI reports that 25% of business persons they surveyed admitted to covert intelligence gathering about competitors. Among the data likely to be encrypted in the near future are: personnel files, customer files, project reports, market intelligence, bids and proposals, contracts, credit authorization, internal financial/ accounting reports, strategic plans, market forecasts, and financial records.

- Aids to the handicapped through telematics technology are on the brink of a major improvement. Most of the problems of the handicapped are afferent problems, efferent problems, or central processor problems—problems of getting information in, getting controls to work, or processing information in the head. These are the language, the concepts, and the technology of telematics.

- ESS systems (electronic switching systems) are entering into major central telephone systems in a way that give unbelievable systems flexibility. The capability to convert from analog to digital form, process the message, deliver it, and reconvert it to analog form is just one of the ESS's accomplishments.

- Mobile communication systems are on the move. Mobile cellular systems hold a technical promise of being able to have vastly greater numbers of users on mobile systems. This is because it is now technically possible—effectively, efficiently, and with less cross talk—to pack mobile users in greater numbers into a given geographical area. In principle, all the things you had to sit down at a fixed station to do previously can now be done anywhere, at anytime. Mobile cellular systems open up the possibility—in conjunction with some of the other technologies—of the equivalent change from carving in stone to going to paperbacks in one generation.

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EXHIBIT 3-7: ANCILLARY DEVICES

- Credit cards
- Social Security numbers
- Voting devices
- Master/slave manipulators
- Transducers
- Electrical/electronic implants
- CAT scanners
- Analytical and monitoring devices
  - chemical
  - physical
  - biological
- Man/machine interface

ANCILLARY DEVICES

Telematics is a flexible, protean, growing area. But even it has ancillary technological developments which will interact with it. Exhibit 3-7 suggests some of these devices. How they will interact remains to be seen. The key feature is that separately and together these devices are the instruments for weaving human, natural, and social organisms more closely together. For example, credit cards are now being developed that have their own brain on a chip incorporated into them. Social Security numbers may be the first step in individual identifiers—perhaps usable in such things as energy rationing, work passes, security systems, etc.

- Voting devices are now going well beyond the low technology of the voting machine. It is now possible for people in small group meetings to vote anonymously, instantly, and in real time. On cable systems, they can vote collectively on a large scale, anonymously, and also in real time.

- Master/slave manipulators, as a branch of automation and robotics equipment, permit actions to be taken in one physical place (control headquarters) and to be manifested on an enormously larger, the same, or smaller scale somewhere else. The manipulation of physical devices from earth, on the moon, in space, in the deep oceans, in mines, or inside the body, is not a promise—it is real.

- Transducers (devices which convert signals from one medium to another) are central to telecommunications technology. But we are now coming to understand the transducers in animals, and to develop new transducers unknown to previous technology, and unknown in nature.

- From a biomedical point of view, electrical and electronic implants in men and animals are already well-known and may become more significant. Analytical devices in the chemical, physical, and biological sciences are proliferating at such a rate and to such a degree of fineness and sensitivity in control that they are themselves subjects of independent scientific journals. The capability to use

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PAGE NUMBER
EPA-287 (Cin.)
(4-76)

these techniques for analysis and monitoring is the opening wedge of a new level of control over the natural and man-made environment. CAT scanner is one example of a new diagnostic device which combines x-rays, computers, and microprocessors to give an incredible new leap forward in diagnostic capabilities.

- Finally, man to machine interfaces, by which people can interact with devices, is the subject of new refinements. We all sat in awe and wonder as children at the one-man band capable of playing music with ankles, toes, knees, elbows, wrists, mouth, and head. The one-man band is perhaps the faint prototype of what man/machine interactions may hold when it will be possible to convert a person from a linear information receiver and processor into a multidimensional polytransduced information receiver, processor, and activator.

BIG TELEMATICS SYSTEMS

Discussion of specific technological advances is necessarily prefatory, because the meaning of any technology is changed when it is harnessed with other technologies into a new system. For example, it is useful to know what a microprocessor can do in general, but it is hard to grasp the real impact of microprocessor technology until you can see it applied in an assembly line or an automated office. A telematic system is a set of equipment, procedures for its use, people who use the equipment and procedures, and the rules which govern the complete process. Whatever its function, it is synergistic in that the impact and power of the system as a whole are greater than the sum of the components' power and impact. This section describes some telematic systems which appear to have great potential consequences.

This section illustrates some of the new telematic systems which are coming into use, shows how they developed, and explores what their meaning seems to be. It is important to remember that these systems are so new and so different in their power and versatility that we do not know and cannot predict where they will lead. But we can scope out some possibilities.

The goal of this study is to focus as much rigorous thinking and empirical knowledge as possible, to systematically and clearly outline possible and likely first, second, and third order impacts of telematic systems on ourselves and on the natural and man-made environment.

Private Systems for Families and Businesses

Powerful telematic systems, formerly used only by agencies like NASA to explore outer space, are suddenly available to families and businesses at a cost which many can already afford and which seems likely to fall lower. Such systems allow people to communicate in real time with virtually anyone in the world using voice and sight. They give instant access to organized bodies of information. All the most current information is instantly available—from world news to financial information. Additionally, this information can be manipulated to make many useful calculations.

EPA-287 (Cin.)
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What will it mean to have such systems in most homes and businesses? One result will be what is now referred to as the office of the future. The development of very large computer memories in combination with microprocessors allow a real revolution in office work. Less labor and less paper will be required through the use of large message switching systems which can shuttle messages within an extensive network of offices, store them, and print them out on request. Microprocessors have turned typewriters into text editing machines. In this sort of office, many jobs will be eliminated, others upgraded, and new ones created. Because physical proximity between many work stations could be so unimportant as to be irrelevant, the office could be organized differently in scores of places at different locations. In contrast, computer systems allow much more centralized control over complex processes. The authority structure of organizations may well change to centralize power.

Telematics will affect many jobs which are thought to be too dangerous or unpleasant for humans to perform. For example, robots can be used to mine minerals, to handle radioactive materials or other dangerous substances, to wash the windows on skyscrapers, to maintain suspension bridges, etc. They can also be used on assembly lines to replace striking workers. If this happens, and it is quite likely that it will, then the whole structure of our economy will be altered. While there may be fewer jobs in all, more jobs will require high technical skill and thereby have higher intrinsic interest.

A third result will be the wired family. People can work from their home information systems instead of going to the office. Children can be educated through home units. Family members may never be compelled to leave the home—desire may prevail. When the average family has access to as much information as General Motors or the local government, or the local bookie, things will change.

Some generalizations can be seen. Telematics for the masses may reduce the differences between large and small units. For instance, small businesses will be better able to compete with large ones. There may be less value, and perhaps less incentive to organize on a large scale. The ordinary person can have more direct control over information. One could get the news direct from a satellite without benefit of network editing and analysis. One could do without stockbrokers and travel agents. At the same time, because the handling of information will be largely invisible in the sense that it will be stored in a form that requires translation, the possibility of undetected chicanery grows. While differences in some kinds of power at the upper end of the scale may be reduced, the gap between the poor and the middle class will increase. Those who cannot afford access to telematic systems will be more and more disadvantaged. In general, while we cannot pin down exactly which changes will occur, it is clear that widespread availability of telematic systems will produce profound and far-reaching social, economic, and political changes.

Information Supply Systems

Private information systems are worthless without information to put in them. While a good deal of information which they process, for example business records, is privately generated, much of it is not. There is a need for special purpose software packages and for large, on-line data bases.

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PAGE NUMBER
EPA-287 (Cin.)
(4-76)

These data bases could supply current information on stock market prices, entertainment and sports activities, and continuous news and weather. They could also supply directory information for community services, bibliographic data bases, and other data. They could also supply lessons or learning packages of various sorts. The possibilities are endless. At present, the technology for these private information systems is available. However, it will be widely implemented only when there is a sufficient supply base and the market.

The information supply can come from private suppliers like the Infomart system which is designed to interface with the Canadian Telidon system. Or, it can be publicly owned and developed, in which case it is known as a public information utility. In either event, its development requires quite a large information base which is appropriately indexed for retrieval, and kept up to date. The system would also need a large computer to process the information, a staff of people to operate and maintain it, and a means of transmitting the information to subscribers. The power of the system lies in giving people access to and the means to manipulate a far greater body of information than ever before.

Electronic Funds Transfer

EFT systems allow traditional banking functions to be carried out from a distance, very quickly, and without shuttling pieces of paper. From the automatic, 24-hour teller window, to larger, inter-bank exchanges, to automatic transfers of funds from one account to another, EFT systems are different in several ways from old-fashioned banking.

First, elapsed time is shorter. Second, security can be both tighter and looser. For example, a person who has a bad credit rating or a history of passing bad checks can be identified far more quickly and easily at a point of purchase. On the other hand, since entry into the system is on the basis of code numbers rather than signature or personal recognition, illegitimate entry can be easier. The size and density of the electronic web which is created by connecting up many of the financial institutions in the world is such that a criminal with access to the system can more easily find hiding places for embezzled funds and cover his trail to the point where tracing a crime, or even being sure that a crime was committed can be virtually impossible.

Third, the opacity of an electronic system to the average user can be even more intimidating than the stuffiest, most self-righteous banker of the past. If an error should occur, the mystification of the system is such that the user may either assume that the system must be right, or else despair of its ever being corrected. Fourth, the possibility of total centralization of financial information raises all sorts of questions of individual privacy and protection of civil liberties.

Electronic Mail

Electronic mail systems are those in which people type out messages on keyboards or feed documents into telefacsimile machines and indicate the recipient. Within a few minutes, the message can be automatically printed out at the recipient's location. Many corporations are finding electronic mail preferable to their former internal word processing and filing arrangements. Several nations are already seriously considering electronic mail operations. Since not all messages need be printed out (the recipient could read messages from the screen and electronically "throw away" the undesired ones), the system could result in some saving of paper. It would also save some fuel. However, it is not at all clear that the system would result in substantial savings over conventional mail systems. But it could be an attractive option in nations which suffer from frequent postal workers' strikes and which have widely dispersed populations. As with EFT, electronic mail raises privacy and security questions. In some nations, particularly those where broadcast communication is already nationalized, they are considering a completely centralized telematics system.

Centralized Communications Systems

Several European nations are exploring the wisdom of centralizing and consolidating their telephone, television, radio, and mail services into one enormous, electronic pie. This sort of system could be augmented with large public information utilities and electronic newspapers. Such a system is likely to boggle the mind of many Americans with Orwellian nightmares. Nevertheless, what is possible is likely to be done somewhere and sometime. What would it mean?

NEW CAPABILITIES

It was observed at the beginning of this section that telecommunications is not new; people have been communicating over distance for some time. But today's telecommunications in convergence with today's computation and information technologies give people and institutions new capabilities. It is important to extract the element of novelty from a developing technology if one is to forecast its more extended impacts. This is so because as a new technology is substituted for an older one and it is adapted, modified, and improved, its outer form is often so changed that only the function remains. Then as other products and systems are changed to better take advantage of the technology, even its function is expanded or developed so that in the end the new capability which the original invention offered is the only thread which can be used to follow its evolving path.

What is useful in tracing back the development of technologies, the concept of the capability, is also a good tool for anticipating its major impacts. If it can be discerned, the new capability can be figuratively tossed forward in time as a vehicle for projecting future impacts. The specific development or non-development of any telematic device will depend on a great number of economic, social, political, and accidental events. The chance of widespread adoption of any particular product or device is not readily calculated. However, many new capabilities can be expressed in several ways by different technologies or technological systems. The capabilities implicit in telematics, therefore, are particularly adaptable to the vagaries of human culture. The chances are quite high that if a specific product or device is not accepted, the new capability it represents will not be lost but will be applied or manifest in some other telematics format.

SOCIAL CHARACTERISTICS OF NEW TELEMATICS CAPABILITIES

Looking at telematics there are a large number of new capabilities, with many quite specific ones mapping onto fewer, more general ones. At the highest level of abstraction there are six.

1. *New control over time and space*. Many telematic devices are so fast that distance becomes a non-factor, allowing virtually instantaneous perception of an event which may be half a globe away or far out in space. The ability to perceive distant events as they occur and to cause distant events to co-occur is new. Another new way to manipulate time is the capacity of digital equipment to store messages and play them later. This permits synchronous use of broadcast messages, and make very likely the demise of "prime time". Already we can see the beginnings of around-the-clock business as people become free to schedule their time in ways that suit them best. Time-sharing computer systems also manipulate time by offering false synchronicity. They manipulate information so fast that humans have the illusion of using the same system at the same time when, in fact, they are queued for short periods between messages. The relative slowness of human information processing similarly allows several conversations to share telephone lines at the same time unbeknownst to the users. The enormous increase in variety, richness and texture of information which can now be transmitted makes it feasible for dispersed individuals and institutions to actively influence and participate in decision-making by reducing the advantage of being physically on-site. This permits new decentralization of authority and responsibility.

2. *New power to obscure*. The simple fact that new telematic systems can be totally paperless means that many transactions can be virtually invisible when they occur and without trace afterwards. Not only can information, funds, or whatever goods the system controls be taken, but one may not know for sure whether or when the theft occurred. Further, such thieves are extremely difficult to track. On the social side of it, electronically mediated transactions can protect one from social discrimination, providing one has opportunity to learn the other system. It may, of course, serve the interests of some to prevent others from learning the system, simultaneously increasing its mystification, and their own power. Fear and alienation need not belong only to those who do not have personal access to a system. Few users will know a system well enough to feel in control. Everyone else is likely to be susceptible to some degree of alienation.

3. *New extensions of human action*. Telematics can extend and to some degree substitute for human capabilities of communication, guidance and control, and use of information to create new information. One aspect of this capability is new operational access to obscure places. Not only can we now monitor and regulate from within machines or living bodies, but as sensory robots are developed we can perform delicate and precise maneuvers in hostile environments such as the deep sea, outer space, underground, or in the presence of toxic materials. In another aspect, with the development of

EPA-287 (Cin.)
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artificial intelligence, computers can be used to monitor and control systems of other computers and consult people only when appropriate. In areas like pattern recognition and encryption, machines can sometimes out-perform people. The ability to build, test, and experiment with models of large systems undergirds our growing capacity to manage complexity, thus extending enormously the size of systems which we may build and control.

4. *New levels of efficiency and productivity*. New telematic technologies are generally conserving of energy, materials, and labor. When they are substituted for other technologies, they are almost always more efficient. They are able to enhance the productivity of other technologies. The uniform product code substitutes for hand stamping of food and merchandise with prices and makes more efficient use of the labeling which is done anyway at the factory on most goods.

5. *New power to connect and disconnect*. Telematics creates networks, linking together previously unconnected markets, regions, industries, organizations, people, or data bases into systems. In doing so they create new interdependencies among the units of the systems. The interdependencies themselves create vulnerability to disconnection.

6. *New power to centralize and decentralize*. With telematics, power need not be associated with distance. Control and authority may be highly centralized even when operations remain, or become, decentralized. Conversely, telematics can allow dispersed people or institutions to actively influence and participate in decision-making, thus decentralizing authority and responsibility. Similarly, the population may be geographically dispersed by substituting telecommunication for transportation. Or, if it should be advantageous to centralize population, telematic control can improve the management of large cities.

Telematics is the agency for making ever more true the observation of Teilhard de Chardin that mankind has added a tangible new dimension to the structure of the earth—to the geosphere, the lithosphere, the stratosphere, and the biosphere. This product, of our own creation, is the noosphere. Technology has given the total knowledge of mankind a virtual independence from any individual, any institution, any location, or any place. Shared and common knowledge so perfuses and interrelates that a new web surrounds and draws the world together. The noosphere, the sphere of knowledge, is a tangible and indestructible part of global life.

As we stand on the brink of this knowledge and information revolution, we find ourselves saddled with every encumbrance of the past. Myopic perspectives, forced by day-to-day pressures and narrow self-serving interests, clouds visions of the future. Nearly total indifference to a future beyond tomorrow by legislators and public and private executives conspire to delay bringing the benefits of modern telematics, first to all Americans and then to all of mankind. Many fears—such as that of mass propaganda, invasion of privacy, information overload, mind manipulation, technological unemployment, trivialization by making the important accessible—reflect the mismatch between these modern wonders and old frameworks. The excitement and the promise of a technological revolution is not in how it will disserve the old

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EPA-287 (Cin.)
(4-76)

and established, but in how it will transform the old and create the new—including new values, new needs, and new levels of human fulfillment.

SECTION 4

THE SOCIETAL CONTEXT OF TELEMATICS: LONG-RANGE TRENDS

National and international trends and conditions will affect the pace and pattern of telematics' development and the kinds and significance of its impacts. The first part of this section discusses indications that society is in the midst of several transitions. The next part identifies economic and social trends that will push telematics' development, and some which may inhibit it. The third subsection describes trends related to the environment, EPA's mission, and telematics; it concludes that public support for environmental protection will not decline significantly in spite of changing political attitudes.

Two exhibits display relationships between long-range trends and the future of telematics.

WHY LOOK AT THE SOCIAL CONTEXT

The world of the next few decades will be the product of trends noted in the past, as well as events which occur in the future. The relationship between social change and technological change is a two-way street. Society—its needs, values and culture, laws and institutions—guide the path and direct the pace of technological development either deliberately or without intent.

National and global trends and conditions will strongly affect:

- the pace of telematics development and adoption;
- the degree of market penetration;
- the magnitude and significance of benefits and costs;
- the way in which those benefits and costs are generally perceived, and therefore the public acceptance of or resistance to telematics.

As already noted, this study attempts no product-specific, quantified market projections. The capabilities offered by telematics are so diverse

EPA-287 (Cin.)
(4-76)

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and overwhelming that, short of a general societal collapse, it is inconceivable that modern telematics will not be adopted and adapted to nearly every institution and activity of our society sooner or later. Particular applications may be delayed or blocked, but there are a nearly endless number of combinations of elements, functions, devices, and systems to provide equivalent services and capabilities. The pattern and timing of adoption, the way social institutions adjust to telematics, and the changes engendered thereby are more uncertain—at least during the next two decades. Consideration of long-range national and global trends can discharge some certainty by helping to understand the actions of major stakeholders in telematics development.

Because American society is so technologically multifaceted, socially diverse, and institutionally pluralistic, the trends which might be discussed are almost without number. A trend, after all, is only a perceptual and conceptual template used to impose a rational pattern on a bewilderingly richly textured field of data. And for every trend which is identified, there are likely to be countervailing trends or contrary pressures.

In addition, the period from 1970 to 2000 seems likely to appear, in retrospect, as one of those times in human history when many trends of long and stable duration approach saturation or undergo sharp inflections. One factor in particular is having a profound effect: the recent realization that the non-renewable resources on which Twentieth Century industrial society depends, especially fuel and non-fuel minerals, are not infinite. Although ultimate limits are not in sight, readily available, high-grade deposits of many materials are becoming more difficult to find and recover, and the costs of these raw materials have therefore risen sharply or will do so in the future.

A second factor is the increasing stress imposed by accelerating global population growth on the world's natural support systems: forests, fisheries, crop land, grasslands, wet lands, and the regenerative quality of the natural environment—especially air, water, and soil quality.

Third, the breakup of the political dominance of two major world powers which prevailed at the midpoint of this century, and the demands and increasing power of the Third World nations to control their own resources and pursue their own national economic and political objectives, create powerful uncertainty about the continuation of long-range trends.

Daniel Bell, Zbigniew Brzezinski, Bertram Gross, and others have attempted to identify those trends which will create the information society of the future, using concepts like "post-industrial society," "the technotronic age," and "friendly fascism." Their models may be persuasive, but they leave largely unanswered the questions of how we move from here to there, and whether there are other equally plausible futures. We recognize that there have been periods in history which were major transition points for society—the Renaissance and the Industrial Revolution, for example. Whether such societal transitions can be seen and described while they are in progress is an open question for many thinkers—but not for all.

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PAGE NUMBER
EPA-287 (Cin.)
(4-76)

We must also bear in mind that unexpected and unplanned, even unforeseeable, events can abruptly abort or reverse many long-established trends. A "big surprise" such as a natural disaster, a nuclear war, an economic collapse, or a catastrophic environmental "overshoot" (to use the language of "Limits To Growth") cancels all bets.

What set of long-range trends—or what formulation of long-range trends—is most important to keep in mind when discussing the future of telematics and its effects on society and the environment? Bearing in mind the significant characteristics of the technology which have been identified, we can consider some trends which bear on the related social patterns and institutions. To review, those characteristics of telematics, which were discussed at some length at the end of Section 3, are:

- new control over time and space;
- new power to obscure the inner dynamics of processes, and thus conceal vulnerabilities;
- new extensions of human action;
- new levels of efficiency and productivity;
- new power to connect and disconnect; and,
- new power to centralize and decentralize.

The following subsection discusses some trends which will encourage, and some which may inhibit, rapid spread of telematics (Exhibit 4-1). The third subsection considers some trends directly relevant to EPA responsibilities, and suggests that these responsibilities will not diminish in spite of changing political programs and priorities. A final exhibit (4-2) summarizes a number of national and international trends in relation to EPA's mission.

TRENDS PUSHING AND INHIBITING TELEMATICS ADOPTION

The competitive position of American industry in international markets has been weakening for twenty years. American science and technology, although still strong, do not enjoy the preeminence in nearly all fields which marked the first decade after World War II. Dependence on imports of energy and materials has greatly increased. Rising energy costs, inflation, high interest rates, and uncertain or high regulatory costs have discouraged capital investment, accompanied by a declining rate of productivity growth. Current national economic policy emphasizes recapitalization and re-industrialization. Telematics is generally seen as an effective tool for increasing productivity in manufacturing, agriculture, and services.

The nature of work and the workforce has been changing for some time; manufacturing and agricultural jobs as a proportion of the workforce have declined; production jobs have declined relative to non-production jobs; and more than half of the workforce is in services—usually information handling.

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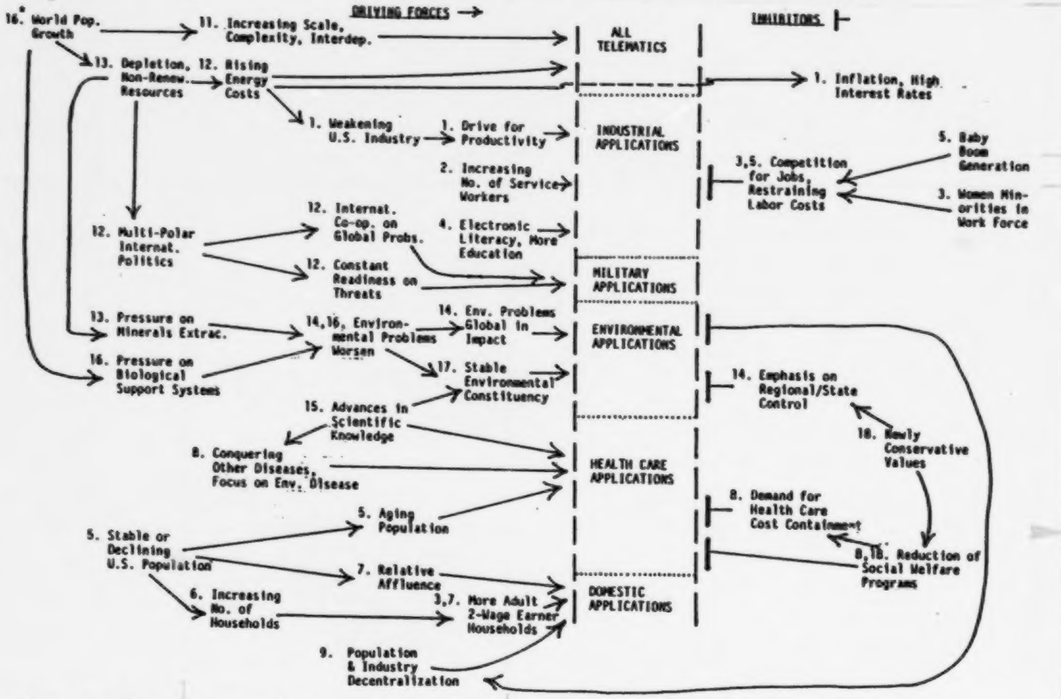
EXHIBIT 4-1: TRENDS DRIVING AND INHIBITING TELEMATICS


DRIVING FORCES →
INHIBITORS ⊢
16.* World Pop. Growth
11. Increasing Scale, Complexity, Interdep.
13. Depletion, Non-Renew. Resources
12. Rising Energy Costs
1. Weakening U.S. Industry
1. Drive for Productivity
2. Increasing No. of Service Workers
12. Internat. Co-op. on Global Probs.
4. Electronic Literacy, More Education
12. Multi-Polar Internat. Politics
12. Constant Readiness on Threats
13. Pressure on Minerals Extrac.
14,16, Environmental Problems Worsen
14. Env. Problems Global in Impact
16. Pressure on Biological Support Systems
17. Stable Environmental Constituency
15. Advances in Scientific Knowledge
8. Conquering Other Diseases, Focus on Env. Disease
5. Aging Population
5. Stable or Declining U.S. Population
7. Relative Affluence
6. Increasing No. of Households
3,7. More Adult 2-Wage Earner Households
9. Population & Industry Decentralization
ALL TELEMATICS
INDUSTRIAL APPLICATIONS
MILITARY APPLICATIONS
ENVIRONMENTAL APPLICATIONS
HEALTH CARE APPLICATIONS
DOMESTIC APPLICATIONS
1. Inflation, High Interest Rates
5. Baby Boom Generation
3,5. Competition for Jobs, Restraining Labor Costs
3. Women Minorities in Work Force
14. Emphasis on Regional/State Control
10. Newly Conservative Values
8. Demand for Health Care Cost Containment
8,10. Reduction of Social Welfare Programs

*Numbers refer to trends. See Trend discussions in Exhibit 4-2.

This trend and the development of telematics are mutually reinforcing.

The workforce is increasingly educated in terms of number of school years completed. The percent with college education is increasing, and more and more young workers have familiarity with computers. Nearly all are accustomed to telematics, from TV and electronic games to automated teller machines. This electronic literacy may reduce psychological resistance to telematics in the workplace.

The rising costs of energy and materials, as easily recovered, high grade deposits become relatively depleted, will encourage adoption of telematics which are generally conservative of energy and materials. Thus, industrial and commercial applications of telematics are apt to lead household market development.

The U.S. will have a stabilizing and aging population over the next two to three decades, and possibly a declining population thereafter. The rate of household formation has been increasing much faster than population, and is more important for domestic applications of telematics. An increasing number of adult households, many with two or more earners, a long-established trend toward increasing affluence and predominantly middle-class lifestyle, and a very slow shift toward more equitable distribution of family income, all argue for a healthy market for domestic and household applications of telematics.

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EPA-287 (Cin.)
(4-76)

Americans in general feel that their health is good, and social indicators point to continuing improvement. However, by some indicators, such as infant mortality, the U.S. lags behind other advanced nations. Americans are increasingly dissatisfied, the evidence suggests, with the quality, cost and accessibility of health care delivery services. Medical diagnostic, treatment, and emergency response applications of telematics will be stimulated by this increasing demand which will be reinforced by increased numbers of older citizens.

The breakdown of two-power dominance in international affairs, and the resulting multiplicity of active participants and conflicting national and regional objectives, has steadily increased the need both for international consultation and coordination, and for 24-hour constant readiness to detect and respond to diplomatic and military threats. Modern telematics is critical for military security, modern warfare, peace-keeping efforts, and day-to-day relations between countries. Both the scale and volume of international economic activities and interdependence of national economies is continually increasing. Military and diplomatic applications of telematics will vie with industrial applications in pacing telematics development.

Two general trends will be strong drivers in all aspects of telematics development. Nationally, the continuing movement toward population decentralization and industry dispersion is both facilitated by and stimulates adoption of telematics. This includes shifts from the Northeast and North Central regions to the Sunbelt, shifts from urban to rural areas and from large cities to smaller cities, shifts from manufacturing concentrations to suburban shopping malls. In all nations and in all aspects of human organization and activity there is a general and steady increase in the scale, complexity, and interdependence of processes, institutions, and economic units. Telematics and the trend toward complexity reinforce and feed each other.

For most of these trends, however, there are some counter-forces and some important uncertainties. Continuing inflation and high interest rates or a major depression would be likely to delay the telematics revolution for some time. Although the U.S. population is growing at a sharply declining rate, the baby boom generation is now entering the workforce in unprecedented numbers. In addition, women are increasingly entering the labor force, and this trend is likely to continue. There is also a new wave of immigrants, and a tendency to postpone retirement because of inflation-depleted pensions and threat of reduced social welfare programs. Competition for jobs could tend to slow rising labor costs, and thus reduce some of the motivation for industrial adoption of telematics. Unless the economy is strongly expanding, telematics may not result in a net increase in employment as earlier waves of automation have done. It is, in fact, likely that the number of entry-level, unskilled, and semi-skilled jobs will decrease, and at a time when more are needed to provide experience and channels of upward mobility for groups entering the workforce. In the worst case, worker resistance to telematics, rising social conflict, and neo-Ludditism could result. The adverse impacts on employment opportunities could become an inhibitor to telematics adoption.

Inflation and/or recession, by eroding discretionary income, will also slow penetration of the household market. There is already evidence that

EPA-287 (Cin.)
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real income has declined in the last five years. In the case of health care applications, emphasis now being placed on cost containment and possible reductions in social welfare benefits—including Medicare and Medicaid—may inhibit development and adoptions of telematics.

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TRENDS RELATED TO THE ENVIRONMENT, EPA'S MISSION, AND TELEMATICS

Environmental problems are increasingly international, and even global, in scope, as a result of the increasing scale of modern industry and technology in advanced nations, the spread of industrialization to Third World countries, and depletion of biological support systems as a result of population pressure. Some of the trans-national problems, such as acid rain, are becoming international issues between countries. International concern for global problems will increase the need for monitoring and sharing data between nations.

The ability to detect and monitor slow-building, long-range, and low-level cumulative health effects of pollutants is increasing, and it is outpacing development of control techniques. Further, as medical and biological sciences make breakthroughs in prevention and cure of cancer and degenerative diseases, as they have already with infectious diseases, public attention and concern will increasingly focus on environmental threats to health. This increasing concern will reinforce the need for, and the demand for, environmental management and for appropriate telematic systems to carry it out.

The increase of world population by 75% in three decades, a growth rate which could reach maximum sustainable levels in about fifty years, is straining the productive limits of natural systems: grasslands, crop lands, forests, and fisheries. Increasing demand for water, contamination of ground water, and erosion of soil are serious concerns globally and even in the U.S. The capacity of the natural environment to absorb damage and replenish support systems—its carrying capacity and regenerative capability—is diminished by loss of undeveloped and uninhabited lands. Thus, in spite of advances in environmental legislation and regulation in the U.S., and increasing attention in the rest of the world, environmental problems will worsen.

Indoor environment is a newly important concern which is exacerbated by actions designed to conserve energy used for heating and cooling. One of the relatively few direct environmental concerns associated with telematics is the emission of ozone which will make indoor pollution worse.

Public support for environmental protection programs has been increasing and is likely to continue in spite of a general shift in attitudes against Federal government activism and regulation. As environmental problems become more visible and more threatening, as international pressure to control pollutants which cross national boundaries increases, and as scientific advances continue to reveal cumulative effects of pollutants on health, public concern may well increase. Environmentalism is now well institutionalized in bureaucracies, supporting industries (environmental law, environmental publications), and organized constituent groups, all of which have a strong tendency to be self-maintaining.

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EPA-287 (Cin.)
(4-76)

The renewed emphasis on local and state initiatives and control, and recognition of regional differences, may, however, make it necessary to develop new strategies for carrying out EPA's basic mission and responsibility. Insistence on detailed regulations and standards as the sole strategy is likely to evoke strong resentment and resistance over the present decade.

Exhibit 4-2 relates trends to implications for telematics and suggests some further implications for EPA's mission.

EXHIBIT 4-2: TRENDS RELATING TELEMATICS TO EPA'S MISSION

TRENDS	IMPLICATIONS FOR TELEMATICS	RELEVANCE TO EPA'S MISSION
1. The competitive position of American industry and technology in world markets has been weakening.		
Important factors are aging capital stock, dependence on import of petroleum and critical industrial materials, foreign competition for raw materials and for markets, declining availability of high grade, easily recoverable, domestic mineral deposits, and declining rates of growth in productivity resulting in part from high interest rates, energy costs, regulatory costs, and general inflation. Current national economic policy puts high priority on innovation, recapitalization.	Telematics is a means of increasing productivity in extractive industries manufacturing processes, management, and services. Emphasis on recapitalization will encourage telematics; failure to control inflation/recession would slow telematics.	Massive reindustrialization and recapitalization implies increasing domestic extraction and production of raw materials, increasing volume of production, and increasing levels of mining, industrial, and end-use waste streams.
2. The nature of work and the distribution of employment opportunity has been steadily changing, as the U.S. moves from a manufacturing to a service and information economy.		
The proportion of total workforce engaged in manufacturing and agriculture has greatly declined. The proportion in services has increased to 53%. Automation, especially computers, has generally increased the number of jobs when the economy was expanding; but decreased employment in some job categories and some industries as a whole. Further automation, especially industrial robotics and other forms of telematics, is likely to decrease the number of entry-level, semi- or unskilled jobs.	This trend will reinforce, and will be reinforced, by telematics' adoption.	Indirect, see Exhibit 4-1
3. Women are entering the workforce in increasing numbers.		
This is a well-established trend which is projected to continue. It could be reversed during a period of very high unemployment coupled with relatively high (government) guarantee of family incomes, but this is an unlikely scenario. Women are disproportionately concentrated in low-level, white collar jobs (which may be reduced or constrained by telematics), and in low-level manufacturing jobs where they tend to constitute a labor bank used to buffer fluctuations in the need for workers.	Telematics in many occupations decreases the advantages which males have over females (physical strength, long-established credentials, old-boy networks). But telematics is very likely to decrease the number of entry-level, semi- and unskilled jobs. Continuing entry of women into the workforce may (a) be slowed by telematics' adoption, or (b) by lowering the average cost of labor, remove some of the impetus for telematics' development.	Indirect, see Exhibit 4-1

EPA-287 (Cin.)
(4-76)

EXHIBIT 4-2: TRENDS RELATING TELEMATICS TO EPA'S MISSION (cont'd)

4. American workers are staying in school longer but may not be proportionately better educated. Average number of years of schooling has been increasing for many decades, and about 75% of the workforce has completed four years of high school. Test scores indicated that the quality of education may be declining. But younger workers have been liberally exposed to telematics, usually even computers, since childhood.	Younger workers may be less likely to seek the unskilled or semi-skilled jobs which can be replaced by telematics. If there is a "naturally acquired electronics literacy", this may decrease psychological resistance to telematics. A larger proportion of workers have college training which will increasingly include familiarity with computers.	Indirect, see Exhibit 4-1
5. U.S. population is stabilizing and could even begin to decline in the future. Most demographers expect a gradual return to the long-established trend of a slowly declining birthrate, following a "baby boom" (1945-65) and a "baby bust" (1965-?). But if the baby bust continues, the population could begin to decline during the 21st Century. The current too-large generation will cause intense competition for jobs for the next few decades. The population is aging, but the ratio of dependents to workers is decreasing.	A stable or declining population, predominantly adult and with relatively few dependents, may provide an excellent market for telematics. However, increasing competition for jobs for the next few decades may tend to constrain labor costs and reduce some of the impetus for adoption of telematics by industry.	The changing age structure of the population could imply changes in demands made on the environment, e.g., less emphasis on recreation, open space, and wilderness lands, more emphasis on urban and indoor environments (which may be affected by telematics).
6. Household formation is increasing much more rapidly than population. The average number of people per household dropped in one generation (1940-78) from 3.7 to 2.9. Important factors are divorce, single parent households, increasing numbers of elderly living alone, households of unrelated adults, etc. Rising housing and energy costs may slow the rate of household formation, but it is likely that more households would consist of earning adults.	Domestic utilization of telematics is probably more dependent on household formation rates than on absolute population growth. An increasing number of affluent adult households would expand the telematics market.	Larger numbers of households implies greater per capita consumption of materials and per capita waste production, increased construction of housing, and generally greater stress on the environment. There may be more emphasis on indoor environment as new houses and apartments are made more airtight.
7. The U.S. Population has become steadily more middle class and affluent. Taking education, income, and occupation to be indicators of social class, Americans are overwhelmingly middle class. Per capita income in constant dollars doubled from 1950-77, but may have since declined slightly. Evidence indicates a slight gain in equity of distribution of income.	Unless this trend is reversed, there will be discretionary income available for purchase of telematics, and cultural values will support such purchases.	Middle class affluent people make greatest demands for quality of environment and are EPA's natural constituents. They also, however, place great strain on the environment through high consumption rates.
8. The health and social welfare of Americans are by most measures good and improving, but they lag behind some other advanced nations. Most Americans rate themselves as being in good health. Mortality from infectious diseases has fallen sharply, and life expectancy has been increasing since 1900. By some measures, such as infant mortality, America lags behind other industrialized countries. The costs of medical care have escalated. Social welfare programs in the U.S. are below those in most other advanced nations. Current political attitudes point to a desire to reduce or constrain social welfare guarantees and benefits.	Increased demands on medical care would encourage medical applications of telematics. But emphasis on cost containment may constrain their adoption.	The conquering of infectious disease and progress in reducing degenerative diseases or cancer will tend to focus public attention and concern on diseases associated with environmental causes.

EPA-287 (Cin.)
(4-76)

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EXHIBIT 4-2: TRENDS RELATING TELEMATICS TO EPA'S MISSION (con't)

9. Population is shifting toward the Sunbelt and away from concentrated urban areas to rural areas. For the past 15 years there has been strong movement toward the South and West. In addition, population is shifting from larger to smaller cities, from metropolitan to non-metropolitan counties, and from urban to rural areas. This progressive decentralization appears to stem from a large variety of factors related to land, housing, and energy costs; differential tax rates; urban congestion, crime, and pollution; changing lifestyles; and a triumph of cultural values and preferences over economic factors which have become less important than they once were.	Improved telecommunications permit and facilitate decentralization rather than drive it. Telematics can allow functions and activities to be dispersed while control and guidance is centralized. Thus decentralization and telematics' adoption are likely to be mutually reinforcing.	Population decentralization changes the nature of demands and stresses on the environment. Concentrations of people and industry may impose insults which exceed the carrying capacity of the environment and overwhelm efforts at control. However, decentralized population may invade fragile environments such as arid lands, reduce the amount of undeveloped lands which serve as recharge areas, and disperse pollutants more widely, making monitoring and control more difficult. Telematics can help to overcome this difficulty.
10. There is a long-established trend toward political centralization in the U.S., periodically balanced by renewed assertion of regional self-determination. Slow but continual change in the direction of nationalization of problems, issues, policies, and institutions has been the pattern throughout American history. Some of the factors involved are economic integration of markets across state lines, improved communication and transportation systems beginning as early as the 1830's, high rates of population mobility, steadily increasing scale of media coverage of political issues, and the desire of dissatisfied interest groups to move issues beyond the influence of local value systems and power groups, e.g., civil rights. However, real differences between regions, as well as political actions by groups threatened by Federal policies, regularly lead to periods of increased emphasis on state and local prerogatives. At present the pendulum appears to be swinging in this direction.	As noted above, telematics can facilitate decentralization and allow a high degree of flexibility to meet local conditions. At the same time, the capability to maintain centralized control over highly dispersed activities could tend to frustrate real decentralization of decision-making.	By providing centralized and integrated data banks and analytical support services, EPA could assist local, state, and regional management of environmental resources.
11. The scale, complexity, and interdependence of all human enterprises is increasing. There is a well-established global, as well as national, trend toward increasing scale and complexity in all organized human activities and institutions. This is driven by population growth, economic interdependence and specialization, and the ability of modern telecommunications and transportation to nullify barriers of time, distance, and language in establishing relationships between geographical regions and dispersed activities. Increasing scale can be demonstrated in farms, markets, industries, political units, buildings, infrastructure design, managerial control, and a host of other institutions and processes. National economies and currencies are increasingly intermeshed.	The tying together of separate units by transportation and communication services allows them to coalesce into large systems and institutions. The efficient governance of such large systems then requires further use of telematics. This trend and further telematics' development are mutually supportive.	The environment itself is a large, complex, interdependent system; telematics can help environmental protectors match this complexity for monitoring and management. Large complex human systems generally create large scale environmental stress.

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EPA-287 (Cin.)
(4-76)

EXHIBIT 4-2: TRENDS RELATING TELEMATICS TO EPA'S MISSION (cont'd)

12. International relations and military security reflect this increasing scale and complexity. Modern communications allowed the development of international cooperation to deal with transnational problems. They also allowed--and thereby made necessary--the consideration of local affairs in the context of multinational rivalries and objectives, the use of public information as a weapon of diplomacy and of war, and constant readiness and instant response to any threats.	Further development of telematics is central to modern diplomacy, warfare, and peacekeeping. It is likely that national security considerations will be a major driver of telematics development.	N.A.
13. The real costs of energy and raw materials is rising and will continue to rise. A long-established trend toward declining energy costs was reversed in the last decade. The real costs of most raw materials will rise in the future quite apart from the effects of any possible actions by supplier nations. Known deposits of high grade, easily accessible ores will gradually be used up, and it will cost more to recover dispersed or lower grade minerals even with improved technologies. There will also be increasing competition for world resources.	Energy-conserving and materials-conserving applications of telematics will be stimulated. But any large requirement for strategic and critical materials for production of telematics devices could inhibit their development.	Increased domestic extraction of dispersed minerals or increased secondary recovery will tend to increase the environmental costs, as well as the direct monetary costs of assuring materials supplies. There will be pressure on EPA to reduce regulatory costs or barriers.
14. Environmental problems are increasingly international and even global in scope. This is largely the result of the increasing scale of industry in advanced nations, and the spread of industrialization to Third World countries. Examples of problems which cut across national boundaries or invade the world's commons are pollution of oceans and aquifers, oil spills, acid rain, increases in atmospheric CO_2, and the potential for radioactive fallout.	International concern about such problems will increase the need for telematics for monitoring and for sharing data among nations.	EPA work will gain a new international perspective and the agency will be called on for assistance in formulating policy with regard to these problems.
15. The ability to detect and monitor slow-building, long-range, and low-level but comulative health effects of pollutants is increasing; it has outpaced control technology. This results from rapid advances in scientific knowledge and instrumentation. Recently developed analytical techniques allow detection of previously undetectable levels.	Environmental monitoring will push the development of telematics.	As other causes of disease are reduced, Americans are likely to pay more attention to diseases associated with environmental causes.
16. Environmental support systems and renewable resources are under intense and increasing pressure. World population increased 75% in the last three decades and could reach maximum sustainable levels in the next fifty years. Forest acreage is declining, grasslands are diminishing, crop lands and fisheries are reaching their productive limits. The number of species is declining. Pressure on water supplies is increasing, and depletion and contamination of groundwater is already a significant problem in the U.S. The general capacity of the natural environment to absorb damage and replenish natural systems is being diminished by reduction of underdevelopment and uninhabited lands.	In spite of advances in environmental legislation in the U.S. and increasing attention in other countries, environmental conditions and the problems of environmental management are likely to worsen in the future. This will tend to encourage environmental applications of telematics, both for the U.S. and for other countries.	Public concern in the U.S. and official attention in other countries are likely to sustain basic political support for environmental protection programs and agencies.

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(4-76)

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EXHIBIT 4-2: TRENDS RELATING TELEMATICS TO EPA'S MISSION (cont'd)

17. Public support for environmental protection is increasing and is likely to continue.		
Currently political attitudes appear to support deregulation and a general diminution of Federal activity in favor of state and local control. But evidence suggests that public support for environmental protection will not disappear. Problems, as noted above, are likely to become more visible. Environmental diseases may be better recognized. Most importantly, environmental constituencies are well-established and institutionalized. They are reinforced by law, supporting industries (environmental law, environmental publishing), bureaucracies, and organized interest groups, all of which tend to be strongly self-maintaining.	Continuing need for pollution control technology and monitoring devices will push environmental applications to serve needs of Federal, state and local governments and private sector managers.	EPA's basic mission and basic constituency will continue, but the agency may have to make changes in its implementation strategies and procedures.
18. Values, attitudes, and mores in the U.S. are increasingly diverse, flexible, and unstable.		
In the last two decades, successive popular movements which at first appeared to represent small but highly vocal minorities, have succeeded in mobilizing public opinion and forcing significant and apparently lasting social change (civil rights, environmental protection, stop-the-war, feminism). More politically conservative popular movements (the Moral Majority, Proposition 13) are now enjoying increasing influence. More diversity in life style, dress, speech, arts, and customs and values appears acceptable than was tolerated in the past.	This diversity and instability introduces considerable uncertainty regarding public acceptance or resistance to telematics, at least in the workplace. Either enthusiasm for a new wave of high technology which would reaffirm the superiority of American science and industry, or, on the other hand, a negative reaction against telematics as a tool of the technocratic elite, or "Big Brother", or a destroyer of jobs--or, indeed, both of these extreme views at the same time--are within the realm of credibility.	This trend runs counter to and places caveats on the trend presented just above.

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PAGE NUMBER
EPA-287 (Cin.)
(4-76)

SECTION 5

IMPACTS OF TELEMATIC TECHNOLOGIES

Anticipating future impacts of emerging technologies necessarily rests on a mixture of informed judgment, creative imagination, and extrapolation of current knowledge, rather than on empirical data. This section concentrates on the primary interests of EPA: the biota, public health and safety, and the technoeconomy as the conduit and mediator for secondary environmental impacts. Possible risks of non-ionizing radiation from microwave technology is discussed as a special case. There are three areas where impacts will depend on resolution of significant inadequacies of the social infrastructure for telematics: systems vulnerabilities, technical and legal integration structures, and issues of privacy, security, and access. A final subsection discusses appropriate criteria for evaluating the importance of the potential impacts for EPA research planning.

INTRODUCTION

Section 3 summarized the state-of-the-art in telematic technologies. While all of the technologies are developed, or developing, they are not all in common use now, and the timing of their dissemination will be affected by the social context discussed in Section 4. Because of the uncertainties involved in any discussion of the future, anticipating the potential impacts of technology must involve not only extrapolation of current knowledge but informed opinion and some orderly speculation and creative imagination. The assessment team called this "educating our guesses".

During this assessment we examined well over a thousand documents and reports, and talked with about one hundred experts in all aspects of telematics. We discovered only a few investigations into the longer run and indirect impacts of telematics. Two outstanding exceptions to this pattern are the research into the safety of non-ionizing radiation, and analysis of the extent to which telecommunications may or might substitute for transportation.

Virtually all consideration of the possible impacts of telematics, short-range or long, is focused on their benefits. Some questions have been raised about privacy, civil liberties, monopolistic practices, and the vulnerabilities of some very large-scale systems. In terms of the environment, public health and safety, for many people it is unimaginable that telematics could do any physical harm to living things. This is a not quite accurate perception of the technology.

But indeed the assessment concluded that telematics in general is not only benign but very beneficial; the potential benefits appear to far outweigh the potential costs. There are, however, two caveats. We cannot merely assume that all potential social benefits will automatically be captured by the public. Also, it is not safe to ignore the potential costs we can foresee or to assume that others will not appear. Nevertheless, the potential benefits of telematics are so large as to be difficult to describe, and the potential social costs are as yet either most uncertain or at least poorly understood.

As discussed in Section 2, the short-run effects of new technology tend to arise from its substitution for some other technology in performing a familiar activity or filling a felt need. In the course of this activity, institutions adjust to the characteristics of the new technology; and new capabilities may come to light which in turn stimulate the awareness of further needs. Important, long-range impacts of technologies are likely to result from the new capabilities. It is also important to watch for subtle impacts, which seem insignificant but which are highly aggregative over large populations or long periods of time. Thus we began to educate our guesses by looking for:

- impacts which occur simply from the existence of the technology;

- impacts which occur from the substitution of the new technology for older methods of doing things; and,

- impacts which may occur as the new capabilities inherent in the new technology are exploited.

We further educated our guess by factoring in the likely effect of the economic, social, and political trends on the application of the technology.

The pace of development and marketing with telematic technologies is so rapid that "the future is now". The applications of telematics are happening unevenly but at great speed. Some developments are almost instantly exploited, while others more slowly flower. Therefore, it is difficult to separate fact and conjecture regarding the field as a whole.

Because telematics is a collection of related technologies which have the potential for application to virtually every aspect of life, this analysis assumes that small perturbations in the pace or choice of developments will have limited effect. For example, if insufficient capital or market resistance were to block the widespread use of one technology for several years, it would likely make little difference in the longer run. It is so because the impacts which will be felt after the year 2000 are coming from the exploitation of the new capabilities, common to several telematic technologies, not simply of one technology. To illustrate, there are at least two new methods for fast, distant, transmission of messages; digital coding and (1) transmission via lasers and fiber optics, or (2) microwave transmission relayed by satellite. If development of either one were to be stymied, the

EPA-287 (Cin.)
(4-76)

other would still provide cheap, fast, high-volume transmission.

The goal of this section is to identify the reasonably significant and likely impacts of telematics in the United States in the next 20 to 25 years. They are organized according to the three primary foci of the Environmental Protection Agency: the biota, human health, and the technoeconomy. Dividing the material in this way may introduce some distortion, but some distortion inevitably accompanies a systematic description of any complex matter. Because the study plan is to couch the conclusions in terms of benefits from telematics which may not be realized, and hazards from telematics which may not be avoided unless EPA acts, the impacts are also presented in terms of possible benefits and hazards (see Exhibit 5-1). These benefits and hazards are presented within each EPA focus in the logical order of those which occur: (1) simply from the existence of the technology; (2) from its substitution for older methods; and (3) from its new capabilities.

POSSIBLE IMPACTS ON THE BIOTA

In the biota we include the earth and its air, water, soils, mineral resources and living things, except for human health which will be discussed in the next section, and those minerals, animals, and plants which are the direct object of the human technoeconomy. Among the latter are agriculture, commercial fishing, and mineral extraction, which will be treated in the final portion of this section.

Impacts from the Technology Itself

In all of this research into opportunities and problems, one direct impact of telematic technologies on the biota appears potentially and significantly detrimental: the effects of non-ionizing radiation. Because of the large amount of uncertainty and controversy about this subject, we have covered it as a separate case, discussed in the subsection below.

Aside from this concern, direct impacts from the physical characteristics of the technology (as opposed to those which flow from the capabilities it offers) would be limited to those which flow from the construction of facilities, the manufacturing of devices and hardware, the raw materials required, and the maintenance and operation of systems. In the literature and research reports concerning telematics, there is little written on these subjects but no important concerns appear to have arisen. In general, telematics is a dispersed and decentralized technology requiring relatively few large construction projects, and while a few controversies have arisen about such sites (for example, a 370 ft. microwave radio tower in Wilton, Connecticut, and the SANGUINE/SEAFARER submarine communications sites), the concern has been because of supposed radiation effects. There appears to be nothing in the construction, manufacture, materials requirements, or maintenance of telematics systems which is both unique to telematics and of significant new environmental concern.

EPA-287 (Cin.)
(4-76)

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EXHIBIT 5-1: TELEMATICS—OPPORTUNITIES AND PROBLEMS

	POTENTIAL OPPORTUNITIES/BENEFITS	POTENTIAL PROBLEMS/COSTS
BIOTA	• Monitoring and control mechanisms for air, water, solid waste, noise, radiation pollution control. • Localized traffic control. • Natural resource management (exploration, detection or tracking of minerals, fish schools, herds, forest or crop disease, etc.) • Improved weather monitoring, prediction, and modification. • Reduced pollution from transportation (uncertain).	• Effects of microwave radiation (uncertain). • Future disposal of toxic substances used in some telematics devices.
HEALTH AND SAFETY	• Use of robots in hazardous tasks and hostile environments. • Detection & monitoring of pollutants in workplace. • Detection & monitoring of pollutants in home and office. • Detection & monitoring of pollutants in the environment. • Devices for diagnosis and treatment. • Emergency services coordination and routing. • Remote consultation. • Medical education. • Medical information systems.	• Effect of microwave radiation (uncertain). • Toxic fumes from telematics devices involved in fires. • Ozone emissions. • Physical and psychic stress from VDT. • Increased costs of medical services. • Increased disequities in health care delivery. • Increased impersonality in medical care.
TECHNO-ECONOMY	• Direct economic growth (electronics industry, exports). • Increased productivity in manufacturing, services, agriculture, mining, etc. • Minimization of negative impacts or social dislocations resulting from decentralizations.	• Impact on employment levels (uncertain), reduction of unskilled/semiskilled jobs in some categories. • Retraining of workers. • Disadvantages for some small, undercapitalized businesses. • Disturbance of relationships between management and labor; erosion of constituency for occupational safety.
TRANS-SOCIAL	• New capabilities in large and diverse fields of activity.	• Systematic vulnerability from reliance on telematics. • Need to develop: structures for synthesis of information, more sophisticated programming; revised laws/regulations to fit new activities and new problems. • Need for national and international information/communication policies.

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(4-76)

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Impacts From The Substitution Of Telematics For Other Technologies

There are two primary areas of impact on the biota from the substitution of telematics for other technologies: a cluster of benefits from the use of telematic monitors and control devices and the environmental benefits or stress which may result from substitution of telematics for transportation.

Much of EPA's work involves monitoring air, water, noise, solid waste, and radiation pollution. Older spot-and-check-and-extrapolative methods of monitoring were far less precise than newer telematic methods. Imprecision can lead to errors of too much, as well as too little, restriction. Because they may be remote, telematic sensors can be a good deal cheaper than manually collected samples, so monitoring organizations can use more of them and sample more often, and even automatically randomize the sampling process. Data can be collected from more points. By feeding this data into computerized analytical systems based on sophisticated models, a great deal of flexibility is gained. For example, in water programs, by monitoring a number of pollution-point sources and other points which are not near sources of pollution, it is possible to learn about the effects of specific discharges on a watershed, river basin, bay, or other water system. Such knowledge can be used to inform far better decisions about the management of effluents./1

Similarly dramatic benefits can be gained in monitoring pollution which is due to automotive traffic. The Stanford Research Institute's 1977 report notes that telecommunications facilities themselves are usually unobtrusive, make no direct contribution to pollution, and entail little direct or indirect energy consumption. In one test of the capability to monitor and organize traffic flow via coordination of traffic signals, results "showed a reduction of 30% in vehicle-miles traveled in the morning peak hour for the same number of trips." Among the impacts on the biota, which this implies, is the potential to reduce the "need to build extensive new facilities that may inflict severe environmental damage," such as airports and expanded highway systems./2

Monitors, in conjunction with computer graphics technology, can present a live picture of smog patterns and densities as they develop, just as the smoke in a wind tunnel shows aerodynamic flows. The benefits in dealing with the problem are obvious—particularly hard hit areas of a metropolitan area can be warned, traffic rerouted, or even evacuated. In addition, the dramatic impact to be derived from such displays may help those trying to encourage car pooling and mass transit use. Computer mediated simulation can build on this new level of conceptualization and ability to manipulate knowledge to improve the public's understanding of the trade-offs involved.

In terms of noise pollution, monitoring devices could rapidly determine noise levels and be used in the same manner as a speed radar gun. As the car with the broken muffler rumbles by, an officer could take a reading and present the driver with evidence that a noise ordinance has been violated.

The transportation/telecommunications trade-off. It is generally conceded that telematics has substantial potential to increase "locational freedom for office establishments"./3 In other words, some people would be

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EPA-287 (Cin.)
(4-76)

able to work in their homes; some large offices could be broken up into small dispersed work centers distributed throughout a metropolitan area or even over larger regions; and there would be little reason for similar institutions to be clustered as they now often are—for example, financial districts in New York and London, or Madison Avenue's advertising row. Although in theory telematics could allow nearly unlimited dispersion, the vision of the nation's "information handlers" (now more than 50% of the workforce) all working at home terminals is unlikely in the next few decades. It seems likely that professionals who typically work in a more or less independent way (researchers, consultants, editors, etc.) and some categories of support personnel (e.g., word processors, programmers) would be chiefly affected at first. The literature shows little consensus on how many people this would include. The modularization and dispersal of large offices into smaller decentralized units may, however, have a significant effect eventually in reducing traffic or constraining its growth.

The possibility of telematics replacing some types of transportation is a question of considerable importance. Because so much money is spent on transportation, even a 5% or 10% substitution would have significant results. There has been speculation that as telematic services improve and become cheaper, a more or less direct trade-off will occur.

There has been a good deal of research on people's decisions regarding travel and communication, and many attempts to measure the possible size of a trade-off and its impacts. The research has focused primarily on two areas: the implications of transportation/communication substitution for energy demand, and its prospects for decentralization and its results. We speak to the second subject in a later section.

The two major areas in which people have projected energy savings from the substitution of communication for travel are urban commuting and long distance business travel. Since 42% of all urban transportation is tied to commuting to work, it appears that the ability of telematics to allow dispersal to suburban work areas or the home, and thus reduce commuting, could result in substantial fuel savings. Specifically, "having half of all office employees work in neighborhood office centers six out of every seven working days could save 240,000 barrels (of fuel) per day. If these same employees worked at home...the savings would be 320,000 barrels per day." /4

It seems safe to say, according to SRI, that there would be: (a) "important localized (but not city-wide) reduction in traffic flows, accidents, and air pollution;" (b) "increased potential effectiveness for central area traffic restraint and environmental improvement plans;" and, (c) "relatively slight reductions in noise level subjective effects." /5 Traffic congestion, air pollution, and noise are, city planners believe, among the important factors that drive people out of cities, desolating central business districts and eroding the urban tax base. But improvement of the urban environment by dispersing the people and activities which make it urban would seem to be self-defeating. Whether some balance point can be found and maintained is still an open question.

The question of telecommunication/transportation trade-offs, on long distance rather than commuting travel, has not been satisfactorily resolved in social science research. Kenneth Friedman reports that 50% of inter-city air travel is business related./6 It has been postulated that "if total business air travel were reduced 20%, it would save roughly 50,000 barrels of jet fuel per day...Substituting 20% of all business travel by auto would save another 80,000 barrels per day."/7 Saving this amount of fuel would of course not only reduce oil imports but would curtail air pollution from automobiles to some degree. Reduction in travel could also lead to reduction in future taking of land for highways and airports and therefore less disruption of habitats, soil erosion, highway runoff, deforestation, and noise.

Exhibit 5-2 summarizes the line of research looking to substitution of telematics for travel. However, there is considerable doubt that—if other factors remain the same—this substitution really occurs. The telephone is said to have increased the demand for travel by more efficiently coordinating schedules, routing, and so on./8 Harkness reports, "if the latent demand for travel greatly exceeds the available time and budget, trips substituted by teleconferencing will simply free time and budget to satisfy latent demand."/9 Many observers conclude that past improvements in communications broadened market areas and increased the scale of commercial, social, and intellectual exchanges, which in the long run increased the reasons for long distance travel. The historical evidence is of course confounded by improvements in quality of, and reduction of time and money costs of, transportation during the same period. This improvement, however, may have been reversed recently. Congestion, deterioration of transportation systems or services, increased distance to airports, as well as energy costs, increase the frustration factor. It is possible that this may make substitution for transportation more attractive than in the past.

Most of the work on telecommunications/transportation trade-offs was done before the price elasticity of demand for gasoline became apparent and the price of oil forced Americans to use more fuel efficient cars. Since then, the effects of rising oil prices have become a new primary variable, and this throws much of the earlier research into question. We conclude that energy costs are likely to be a far more important factor in reducing transportation than the existence of telematics. However, as Friedman and Obermann note, "recent substantial improvements in automobile fuel economy...encouraged by foreign competition and high gasoline prices, have for many actually decreased the cost of automobile travel."/10 In recreational travel, "super-saver" airline fares, resulting in part from deregulation, have recently increased vacation travel by airplane; however, the general trend in airfares is up, to reflect energy costs.

In short, there is little evidence that telecommunications substitutes for travel, other factors being equal. That is, telecommunications itself is not a prime driver. However, if higher energy costs and increasing frustration incline people to reduce travel, telecommunications are likely to be a facilitator since it would moderate social disruption.

Automobile applications of telematics, which is already beginning, should contribute significantly to fuel efficiency and to reduction of emissions. It

EXHIBIT 5-2: NONTRAVEL SUBSTITUTES THAT MAY SATISFY TRAVEL-GENERATING PERSON-TO-OBJECT INTERACTIONS

Interactions	Parties	Purpose Of Trip	Examples	Suggested Nontravel Substitutes
Face-to-face	one-to-one	work	private conference	2-way audiovisual
	one-to-many	personal business	visit to doctor	--
	one-to-many	work	speech, demonstration	2-way audiovisual
	several-to-several	work social	conference, family reunion, party	2-way audiovisual --
Written or printed	one-to-one	work	memo, business letter, report	fascimile transmission
Audiovisual	one-to-many	work	presentation or training film	2-way audio-only
Audial only	one-to-one	work	dictaphone	2-way audio-only
	one-to-many	work	paging system	2-way audio-only

Type Of Contact	Nature Of Activity	Purpose Of Trip	Examples	Suggested Nontravel Substitutes
Visual only	inspection	work	meter reading, routine stock purchasing	2-way audio visual or audio plus fascimile
	--	shopping	routine grocery shopping	--
Visual and physical	message orientation	work	typing	fascimile transmission
	use of fixed equipment	work	production line	no substitute
	use of tools and instruments	work	carpentry, plumbing	no substitute
	acquiring goods	work	materials or wholesale purchasing	2-way audiovisual
	acquiring information	work	library research	remote computer services

Source: Friedman, K.M. and Obermann, R.M. Transportation and Telecommunications: The Energy Implications. Annual Review of Energy, 1979 4.pp. 135-136.

is also possible that automated highways—in the long-range future—or somewhat sooner, improved traffic control systems and warning systems installed either on the highway or within the vehicle can both increase the effective capacity of highways, make traffic flow more evenly, and reduce accidents. These improvements would tend to prolong the lifetime of both vehicles and highways, with secondary environmental benefits of materials and land conservation.

The larger question of population and industry decentralization and its environmental effects is discussed in a later subsection on technoeconomic impacts of telematics.

Impacts From New Capabilities Inherent In The Technology

Natural resource management is a primary area where benefits arising from the new capabilities of telematics can be realized. There are many ways to use telematics in natural resources management, and, indeed, the Smithsonian Scientific Information Exchange (SSIE) reports a sharp increase in research into such applications in the last several months./11 With the capability for remote, unobtrusive monitoring, telematics offers us the ability to more soundly manage virtually all of the land in the U.S., 33% of which is now publicly owned./12 This ability, if the Federal government should attempt to extend its active management of undeveloped land, would clash with other trends toward a new federalism and decentralization, and activate a number of latent conflicts.

The satellite program known as LACIE (Large Area Crop Inventory Experiment), organized jointly by NASA, USDA, and NOAA, has proven capable of accurately predicting harvest on the basis of growing season monitoring from space. The capabilities of this satellite also include early warning of changes in production and quality of renewable resources, and thus improved land use classification and management. Conservation practices may be better assessed. Pollution detection and impact evaluation will be enhanced./13 SEASAT, another working satellite monitoring system, has been able to provide geological mapping, information on ocean surface patterns, and detailed water temperature data. Among other uses, these capabilities can aid in locating mineral deposits and allow prediction of areas in which certain types of fish may be found; an impact on the biota which is likely to be double-edged as less fuel is used to catch more fish./14

Detailed and accurate weather analysis and prediction are on-going functions performed by utilities, a capacity which might be used to predict and, with the aid of other telematic devices such as automatic computer-operated gates, control floods. Conversely, telematics may be invaluable in monitoring the need for, and then initiating, irrigation over large areas, ensuring equitable distribution of increasingly scarce water supplies. In terms of wildlife management, remote sensing has the potential to keep track of herds in otherwise inaccessible areas. Monitoring the movements of individual animals tagged with transmitters provides accurate information on populations and movement. This, in conjunction with data on availability of fodder for grazing species, can aid in determining numbers to be culled, optimum times and areas for controlled hunting, etc. Forest fire detection may be enhanced in remote areas. Sensing the heat from orbit, the satellite can tell fire fighters the precise location of the blaze, its magnitude, and the speed and direction of its movement.

POSSIBLE IMPACTS ON HUMAN HEALTH AND SAFETY

Telematics offers the possibility of enormous improvement in human health and safety by improving the quality of health care which can be offered. It can boost the basic sciences which support health care, most notably epidemiology. It can offer new capabilities for promoting health and avoiding injury. It can equalize the geographic distribution of medical services and, by cost containment, equalize services across socioeconomic categories.

There are two general aspects to health—that which is widely viewed as preventive, and that which is directed at treating disorders. We must search systematically for impacts of telematics in both areas. As it turns out, because so much of health care depends on gathering and processing information, telematics is singularly applicable to all aspects of health care. On the preventive side, it can be used to build good health by providing knowledge on how to regulate one's body, as well as how to avoid hazards in the form of environmental pollutants and other pathogens, violent crime, and accidents. In treatment, telematics is being applied to both chronic and acute conditions for diagnosis, treatment, and monitoring. As in our discussion of impacts on the biota, we will review these impacts according to the stages of adoption from which they emerge.

Again, the most controversial and possibly significant direct detrimental impact of telematics on public health and safety is the uncertain risk in nonionizing radio from microwave applications. The reader is reminded that this is discussed in a later subsection.

Health And Safety Impacts From The Technology Itself

There are some direct, potential hazards from telematics. With the exception of microwave radiation, there has been little attention given to health risks or research done to discover the existence and parameters of any inherent threats. The paucity of research is probably due to several factors. First, telematic technologies are almost universally perceived as benign—people are unlikely to spontaneously suspect that they may be hazardous, perhaps because there are few massive moving parts, little noise, and little visible evidence of power being expended. Second, many devices are not yet so widely used that low probability dangers would emerge in noticeable numbers. Further, several of the possbile adverse effects would develop over a number of years or even generations. The types of hazards are:

- exposure to toxic chemicals from telematic equipment;
- exposure to nonionizing radiation;
- physical stress from poorly-designed equipment; and,
- psychological stress.

Several toxic substances are used in telematics equipment: gallium arsenide, selenium, and cadmium sulfide. Gallium arsenide is used as a semi-conductor in diodes and in transistors. Gallium is obtained in very small amounts from bauxite (of which it constitutes about 0.01%) and is extracted during the production of aluminum; it is also sometimes associated with zincblende, magnetite, and pyrite. Gallium itself is not highly toxic, but all arsenic compounds are toxic and must be handled with care. Selenium compounds are quite toxic. They are used in photographic and printing reproduction and selenium is also used in photoelectric cells and rectifiers. Selenium is produced commercially from the anode mud of copper refineries. Cadmium compounds are used in copiers. Cadmium compounds are highly toxic, especially the vapors given off in heating. Severe poisoning is a recognized danger to fire fighters and others when fires involve materials containing cadmium. Cadmium is always associated with zincblende and is extracted along with zinc./15

OHSA regulates mining and manufacturing involving these materials to protect workers. There is no evidence that users of telematic equipment have been harmed by them. However, they may present special risks in the event of office and residential fires./16

Disposal of telematics devices containing such materials is another concern. In the course of this research, many experts were consulted about this topic, and the universal response was that "no one has looked into that." Nor could anything be found in the literature. Inquiries to manufacturers indicated also that little attention had been paid to this subject; but it appears that at present telematics devices and components have sufficient value that they are almost always reclaimed for recycling by manufacturers. It is possible that with the proliferation of telematics this will not always be the case or will not universally be the case. Safe disposal could then become a problem for local governments, and some waste disposal techniques, involving heating, could be hazardous.

Electronic office equipment, and particularly copiers, emit small amounts of ozone from corona discharge. The ozone can accumulate if ventilation is poor. It is unclear yet how much ozone it takes to damage human lungs, but recent studies indicate that repeated exposure to ozone concentrations of 1.0 parts per million causes chronic lung injury to small animals. Ozone problems could be quite easily managed with proper office design. In general, it seems that office design and architecture have lagged behind the rapid pace of change in office equipment./17

In summary, with regard to toxic chemicals in telematic equipment, we are in the awkward stance of being unable either to point a finger or to reassure. We must await further research in these areas. Neglect of these questions appears to be a structural issue which requires community attention rather than a question of personal or corporate blame.

The question of physical stress resulting from use of telematic equipment is an occupational issue which affects operators of word processing equipment and video display terminals. While the stress involved is real, as a hazard it has far less potential for damage than toxic chemicals or nonionizing radiation. It is also far easier to measure and correct. It is basically a human factors issue in the design of terminals and associated equipment. While studies have identified the optimal physical arrangement of equipment, many terminals now on the market are designed otherwise and may cause muscle stress. The degree of resolution of the image on the screen is poor enough that prolonged use causes eyestrain. In May of 1981, the Norwegian Labour Inspectorate introduced draft rules and guidelines for firms which employ people to use video display terminals. They require a break every two hours and recommend that nobody spend more than half their working time with them. They also regulate high frequency sound in the units and require regular eye examinations for workers./18

Recently, the National Institute for Occupational Safety and Health (NIOSH) studied the health and psychic stress of video display terminal operators and non-operator control subjects at five work sites. They report that job content factors and VDT use appear to interact in producing visual, musculoskeletal, and emotional health problems./19

Questions of the physical stress of using telematic equipment easily slip over into psychological stress. The psychological stress of living and working with telematic technologies seems to differ more from person to person than any other direct hazard. Some people, obviously, thrive on telematics. Others are stressed. So far there are several lines of speculation about the cause and nature of the stress, but no firm knowledge. One of these focuses on the inherent alienation from interaction with computers. For example, Thomas Sheridan recently identified seven such factors:

- People compare themselves with computers and worry about their inferiority and threatened obsolescence;
- Computer control alienates by separating human operators from their ultimate task;
- Skilled crafts people who are "promoted" to button-pushers lose their skills, dignity, and self-image;
- Greater access to information and power by the technologically literate puts all others at a disadvantage, including some groups that are accustomed to elite status;
- There is mystification, i.e., the tendency to attribute nearly magical powers to the computer;
- Decisions involve increasingly higher stakes—the costs of failure can be huge;
- Phylogenesis, i.e., the perceived threat that machines may become more intelligent and powerful than humans, can occur./20

In a more generalized way, futurists such as Daniel Bell/21 and Alvin Toffler/22 attempt to show that telematics symbolizes and exemplifies a major cultural watershed, equal in importance to the Industrial Revolution, which will inevitably create a good deal of psychic stress as every part of human culture is changed. In a different, but also quite profound analysis which draws on a substantial body of other work, Mowshowitz/23 puts telematics into the social, economic, and political context of present day Western society. He sees the potential for stress and alienation which is inherent in telematics as aligned with and part of other, more basic, driving forces: the extreme centralization of power in society with technological development as a salient feature of that process, and the reciprocal alienation of individual responsibility.

On a somewhat less grand scale, there is another line of speculation which hypothesizes that working with telematic equipment can be difficult simply because it forces us to accommodate our thinking and working style to the machine rather than vice versa. For instance, one researcher speculates that the stress and fatigue which VDT operators experience comes from the terminals' imposing the need for continual thought on us, whereas most of us naturally think in brief spurts with long rest periods between./24 One could just as easily cite the relentlessly linear logic of the computer in a mismatch with human thought styles.

Health And Safety Impacts From Substitutions And New Capabilities of Telematics

There are many health-related benefits to be gained by use of telematic equipment. Such use is supported by the rising expectations of what is "normal, good health" among the general population, and the increasing willingness of many people to allocate their resources, and even to change their basic life habits, in order to improve their health. Such increasing value and interest in health is part of the on-going trend, noted in Section 4, toward improved health and social welfare. It is supported by the trend toward greater general affluence and an ever enlarging middle class.

Many applications of the new capabilities of telematics to health come from the ability to extend the field of human action, both deeper within our bodies and geographically outward, to remote or medically disadvantaged areas. The same theme of extension applies to new abilities to sense allergens, toxins, and other threats to health. Another set comes from the new capability to manage complexity and information. It allows us to manage our basic understanding of health and threats to it, to improve our management of health care of individuals.

Prevention. One of the more straightforward ways to improve health is by preventing injuries. Robotic equipment and remote controls can be substituted for people in many dangerous tasks, such as firefighting, toxic substance cleanup and control, mining, and tunneling./25

The new capabilities of telematics permit the development of large- and small-scale monitoring for environmental pollutants, toxins, and allergens, thus creating a safer environment. We can expect to reap substantial health benefits from improvement in the quality of air and water on a municipal or regional scale. The health of individual workers can be improved on a workplace-by-workplace basis by use of telematic monitors to detect hazards.

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In the home, the air can be selectively monitored for allergens or toxins. With remote sensors which detect unusual patterns of heat, light, and sound, home security systems will be able to detect dangers and automatically report by telephone to one or more numbers.

The enhanced ability to predict and track violent weather systems, floods, and drought will also help to prevent injuries to people. Building better health is another benefit of telematics. Telematics may permit advances in epidemiology and improved understanding of disease patterns. Electronic biofeedback techniques can give people direct information about their own bodies, and help them to be more self-regulating and thus to stay healthier. Videotape and two-way television systems allow one to get advice and instruction about building health and preventive care at one's convenience. The capability to consult a physician or psychiatrist without the difficulties of travel, perhaps in the privacy of one's own home, and with fewer scheduling problems, is likely to increase people's willingness to seek advice and help for preventive medicine and for health problems.

Emergency care. Telematics brings a new ability to respond to medical emergencies in two ways: through the improved management and coordination of ambulances and other emergency equipment, and through the ability to apply medical expertise faster. Time and distance from treatment are the primary adversaries in medical emergencies. In most areas there are overlapping systems of ambulances and medical evacuation helicopters which must transport people within another overlapping system of hospitals which offer differing special services: shock-trauma units, burn units, neonatal units, etc. The task of managing the emergency vehicles is quite complex, and the cost of a delayed response can easily be someone's life. With satellite assisted communications, and computer mediated allocation models, we will have the potential capability to optimize the management of this resource.

We are now able to equip emergency vehicles with a wide range of monitors which can allow physicians to begin treatment of a patient who is still en route to the hospital. With the cooperation of the attending paramedic, and using satellite relays in very remote areas, the patient's vital signs can be automatically monitored while diagnosis and treatment are begun. With the addition of centralized, computerized medical records, the patient's records may be available at the same time./26

Diagnosis. Often new telematic diagnostic tools both substitute for older methods and offer new capabilities. For example, the wide and growing range of electronic monitoring and scanning devices, which quantify and/or graphically display internal phenomena, in part substitute for other ways of discerning internal states, and also extend the physician's range of perception. This information can be instantly transmitted to one or more distant physicians permitting long-distance diagnosis and easier consultation. There has been considerable work done in telemedicine for the last two decades, including several operating projects and a number of controlled experiments in diagnosis. A review of that work done in 1974/27 shows that even at that time two-way television and an attending allied health service worker produced good diagnoses in a number of areas, including general diagnosis, cardiac auscultation, dermatology, radiology, and psychiatry. The substitution of

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telematics for transportation in medical consultation holds considerable promise for extending medical care to areas which are inadequately served by physicians and for optimizing the services of those specialists whose time is oversubscribed./28 Again, complete, accurate, and quickly accessible patient records can be available to inform the diagnosis. Telematic technologies bring within the range of possibility complete and fully portable medical records in possession of each person. Such a development could protect the privacy of patients and give patients more control over their health. Such a radical change could be expected to engender many other difficulties of its own. This illustrates the intimate relationship between information and power, and also the delicate balance of information distribution upon which our social structure rests.

Exhibit 5-3 displays a range of telematic instruments and implants which may be used for diagnosis and treatment.

Treatment. Many of the same uses of telematics which give us new powers of diagnosis are equally useful in treatment. For example, the substitution of allied health personnel for physicians is possible with telematic backup and instruction. Remote consultation can also be helpful in treatment.

Telematics has made possible the development of prostheses which far exceed the capability of older, mechanical ones. Artificial limbs which respond to electrical impulses in the nerve endings of the severed limb are under development. There are also experimental wheelchairs and robotic devices with a quadriplegic can operate with his breath, lips, tongue or eyelids.

The heart pacemaker was the first of a number of regulators which may be implanted to help stabilize weakened vital organs. Other implants can allow the patient complete freedom of movement while monitoring vital functions and transmitting data to distant medical personnel. Indeed, it appears that the capability now exists to produce implants to regulate or monitor almost any bodily function, and it awaits only the customer demand to warrant the investment of substantial funds for the development effort./29 Implants can be a source of hazard in that under certain conditions other telematic equipment operating in the vicinity can accidentally interfere with their operation and endanger the health of their user./30

General Impacts. There are some general benefits, like computerized medical information systems, which can facilitate the entire health care process. Another is the improvement of medical education, where television is particularly helpful as a teaching aid. The use of telematic technologies can be integrated into the curriculum from the start. Videotapes have already made continuing medical education far easier by allowing one to do the work in one's own home or office and on one's own schedule. In this way, the best instructors are accessible to more students as well.

A major source of indirect benefit to all of health care is the contribution which telematics can make to basic science. For instance, with the ability to collect data worldwide and analyze great masses of it, we can expect advances in epidemiology which will then help in the prevention,

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EXHIBIT 5-3: BIOMEDICAL TELEMATIC INSTRUMENTS

Location	Function				
	Research	Diagnostic	Monitoring	Therapeutic	Prosthetic
Subcutaneous	Microelectronics for totally implantable telemetry of flow, pressure, and dimension, for example	Totally implantable telemetry for coronary bypass graft monitoring	Cerebral pressure telemetry microtransducers and electronics	Microelectrodes for neural stimulator for pain relief	Cardiac pacemaker microelectronics; auditory prosthesis microelectronics
Supercutaneous	Microtransducers for animal backpack telemetry of flow and pressure, for example	Ingestible *p*H telemetry capsule	Ambulatory care ECG telemetry with active microelectronics	Microelectrodes and electronics for bladder stimulator	Hearing aid
Percutaneous	Implantable biopotential and temperature microtransducers with externalized leads	Catheter-tip blood gas sensor	Transvenous pacing lead for monitoring and stimulation; catheter-tip pressure sensor	Electrical stimulation of bone for enhanced healing	Microsensors for left ventricle assist device
Transcutaneous	Gamma ray microtransducer arrays for radioisotope imaging; blood pressure sensor array with piezoresistive microtransducers	Computerized x-ray tomography detector arrays	Piezoelectric transducer arrays for ultrasonic imaging; blood gas monitor microsensors	Microtemperature sensors for hyperthermia; microsensors for defibrillators	Microoptical sensors and tactile stimulators for optical-to-tactile reading aid for the blind
Extracutaneous	Electron microscope	Mass spectrometer; cell sorter	Miniature silicon gas chromatograph for breath analysis	Microsensors for kidney dialysis machine	Voice-actuated wheelchair controller

* Source: J.D. Meindl, in Science, 17 October 1980. p.264.

diagnosis, and treatment of disease. Similarly, the improved ability to collect data, transmit it, analyze and interpret it, will bring new understanding in other areas as well.

There are also some general problems which may result from extensive applications of telematics to medicine. Interference between telematics devices within the hospital, and interference between medical telematics and other communication systems outside, could result in unanticipated breakdowns, data distortion or destruction, and other failures which, in medical practice, could sometimes be disastrous. This is already viewed as a potentially serious problem by medical practice, could sometimes be disastrous.

Secondly, pervasive telematic capability in medicine may further impersonalize practice, emphasize fragmented responsibilities or large team procedures, and reduce the independence, and possibly the psychic rewards, of individual practitioners.

Telematics may enlarge the difference between a relatively few, large, well equipped medical institutions, and many smaller, less well capitalized institutions. This in turn could contribute to disparities in medical care available to rural versus urban areas and the poor versus the more well-off citizens. Finally, telematics could further stimulate the cost of medical care, which has been rising much faster than inflation and has already made cost containment a strong national objective.

None of these potential negative impacts are inevitable. They should be looked at as agenda items for public policy formulation. Some of these problems may be resolved or alleviated within the private/professional sectors of society; others may require government involvement to prevent social costs from seriously diminishing social benefits.

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(4-76)

THE SPECIAL CASE OF MICROWAVE RADIATION

One direct impact of telematics which is thought by some to be potentially hazardous to health and safety and to the biota, and has already become somewhat controversial, is microwave radiation. It is beyond the state of current scientific knowledge to make a definitive, precise statement about the extent and significance of this risk, which would be useful and generally acceptable to scientists, much less to the concerned publics. While there is public concern, it has not as yet coalesced into a politically important issue. There are also indications that if the Federal government does not provide guidelines or standards, some local governments may move to regulate in this area even without scientific consensus to what extent there is a hazard. Such action could delay the development of some applications of telematics, and also disrupt some existing telematics systems and retard productivity growth.

The basis of controversy. Electromagnetic radiation consists of a vibrating electrical field and a vibrating magnetic field moving through space in the manner of waves through water. The radio, microwave, radar, infrared, visible light, and ultraviolet regions of the electromagnetic spectrum are spoken of as "nonionizing", as opposed to radiation at the upper end of the spectrum (beta rays, x-rays, and gamma rays) (see Exhibit 5-4) and particles and radiation emitted by radioactive substances, which are ionizing. The lower end of the spectrum—radio, microwave, and radar radiation—has the longer wave lengths, and these forms of radiation can be produced by oscillating electrical circuits. Microwave radiation passing through human skin and subcutaneous fat into underlying muscular tissue is converted into heat. However, this effect varies with the frequency of the radiation./31

However, microwave radiation, often taken to include VHF, SHF, and EHF bands, which is commonly emitted from TV and FM antenna associated with transmitters and by radar transmitters, varies in frequency from 300 MHz (megahertz) to 300,000 MHz. The controversy over biological effects ranges over the whole radio frequency spectrum (Exhibit 5-4).

Ionizing radiation, which includes x-rays and cosmic particles, can penetrate and disrupt atomic and cellular structure. Nonionizing radiation in contrast passes through the skin with far less energy and is thought to have little effect on cellular or atomic structure. Damage is known to come from the engendered heat, and researchers in the U.S. have generally held that it was for the most part acute but short-term and reversible./32

Some concern began with questions about effects of microwave radiation on radar operators in World War II. In the last decade there was public alarm over possible hazards of color TV sets and microwave ovens; this popular concern was reflected, and stimulated, by a book by P. Brodeur, The Zapping of America./33 The U.S. embassy staff in Moscow was supposedly worried at one time about excessive radiation from remote "spying" devices aimed at their building by the Soviet government. The concept of a solar power satellite which would beam microwave radiation to earth, has been attacked on similar grounds — the uncertainty of the nonionizing radiation's effects.

EXHIBIT 5-4: RADIO FREQUENCY BANDS

Frequency	Wave Lengths	Band Designation	Typical Uses
300 GHz	1 mm	Extremely high frequency (EHF)	Satellite communications, radar, microwave relay, radionavigation, amateur radio, industrial, scientific, medical (ISM)
30 GHz	1 cm	Super high frequency (SHF)	Satellite communications, radar, amateur, microwave relay, airborne weather radar
3 GHz	10 cm	Ultra high frequency (UHF)	Short range communications, amateur, taxi, police, fire, radar, citizens band, radio navigation, UHF - TV, microwave ovens, medical diathermy, ISM
300 MHz	1 m	Very high frequency (VHF)	Police, fire, amateur FM, VHF-TV, industrial RF equipment, diathermy, emergency medical radio
30 MHz	10 m	High frequency (HF)	Citizens band, amateur, medical diathermy, Voice of America, broadcast, international communications, industrial RF equipment
3 MHz	100 m	Medium frequency (MF)	Communications, radionavigation, marine radiophone, amateur, industrial RF equipment, AM broadcast
300 KHz	1 km	Low frequency (LF)	Radionavigation, marine communications, long range
30 KHz	10 km	Very low frequency (VLF)	Very long range communications, audiofrequencies
3 KHz	100 km	Voice frequency (VF)	Voice, audiofrequencies
300 Hz	1000 km	Extremely low frequency (ELF)	Powerlines, audiofrequencies, submarine communications
0 Hz			

* Source: a Technological Review of the Biological Effects of Nonionizing Radiation, a report prepared for the Office of Science and Technology Policy, May 15, 1978.

Other examples of specific controveries can be listed. The Town of Wilton, Connecticut, blocked construction of a 370 ft. radio tower, and the SANGUINE/SEAFARER submarine communications bases have not yet been sited, in part because of public resistance based on fear of microwaves.

However, while FCC staff members told the assessment team that they receive a constant stream of inquiries and statements of concern about microwave from the public, this worry has not yet coalesced into a popular cause or a politically potent issue as has, for example, opposition to nuclear power plants. But it could.

In the last several years, newspapers have been adopting telematics rapidly. The Newspaper Guild, a labor union, at first expressed concern that video display terminals (VDTs) might be emitting x-rays (imaging radiation): then, as the equipment was better understood, shifted its concerns to non-ionizing radiation./34 In 1976, two employees of The New York Times developed cataracts, and since both were relatively young for this disability, they decided it must be more than coincidence. Although the National Institute of Occupational Safety and Health, after investigation, concluded that levels of radiation to which they had been exposed were too low, and at too low a frequency, to have caused this problem, an ophthalmologist took up their cause and has defended their claim in hearings, lawsuits, and the public media./35 Employees of the Toronto Star brought similar charges when several people, who worked with VDTs, gave birth to deformed children. After a number of investigations, the Canadian Minister of Labor officially announced in 1980 that there was no evidence of genetic damage from that radiation./36

A subcommittee of the Science and Technology Committee of the House of Representatives held hearings on VDT in May 1981,/37 and the Food and Drug Administration (FDA) also conducted an investigation. The FDA discounted the possibility of excess radiation from VDTs, saying that such unfounded fears would distract attention from the real, but relatively minor, problems associated with VDT work: eyestrain, headaches, and boredom./38

Ongoing research. There has been 40 years experience with microwave radiation, beginning with concern about radar workers in the second World War.

For years, U.S. scientists found only that for frequencies above 10 megahertz,power densities of more than 100mW/cm^2 were harmful to humans. In 1966, the American National Standards Institute (ANSI) set a 10mW/cm^2 safety limit for workers. Meanwhile, the USSR had a level which was a thousand times lower. Now ANSI has proposed a more stringent duplex standard varying from 100mW/cm^2 to 1mW/cm^2./39

Although the evidence is not conclusive, recent research in the U.S. has begun to reveal a wide range of effects in laboratory animals. These include: morphologic changes in the brain tissue, immunological and behavioral changes, blood chemistry effects, and interaction effects with drugs./40 /41 /42 There is a good deal of ongoing research designed to determine the applicability of such findings to humans and to pin down the nature and extent of any hazards. The conclusions remain quite controversial, particularly in the newer work on low-intensity exposure. For example, in a report prepared for the Department of Energy on the Satellite Power System (SPS)/43, over "1,000 English summaries and two hundred original (or translated) papers" were reviewed./44 Sol Michaelson performed a similar task for the IEEE in 1980, reviewing many of the same documents; Glaser, Cleveland, and Kielman for the Society for Occupation and Mental Health./45

Possible microwave radiation problems are of paramount importance because most developing telematics technologies depend at some point on microwave

EPA-287 (Cin.)
(4-76)

transmission. If microwaves should prove to have irreversible effects on some broad class of living things, the effects would be likely to cascade through all forms of life. Therefore, it is good that research in this area is proceeding, but the pace may be too slow and the scope too uncoordinated to meet the needs of public policy.

Potential microwave related impacts on the biota include behavioral changes such as the heightened submissiveness noted in radiated chickens;/46 interference with birds' and insects' navigational ability, as postulated by Burks and Graf in relation to a 300-meter tall TV antenna which seemed to disorient and attract birds/47; the ability of some species to detect and avoid high levels of microwave irradiation, as did the parakeets studied by Tanner, et al., which often avoided an irradiated area that contained food despite their hunger /48 /49; and pit vipers, which are highly sensitive to thermal energy./50 There is also the large unstudied issue of effects on flora, where research has generally been focused on high level radiation and seed germination or weed control. One study did show that plants may have an advantage over fauna in their ability to thermoregulate through transpiration. /51

It has been shown by Baranski and Czerski that chromosomal and mitotic abnormalities can be expected to result from high intensity microwave radiation, but that levels below 10mW/cm^2 produced no genetic effects. They caution, however, that there is insufficient data to state this conclusively for long-term, low intensity exposure./52 Dr. Radhi S. Dwivedi at Howard University is currently conducting research on potential damage to cellular structures resulting from microwave exposure. His findings on single cells, while not conclusive, point to chloroplast and mitochondria damage at levels of 10mW/cm^2. Mature bean plants were less susceptible to this damage than were young ones. In whole-animal studies, Dr. Dwivedi has found damage to cell membranes and to mitochondria. Interestingly, he found that a 60% to 70% reversal of damage followed cessation of exposure./53

Many of these questions become both compounded and more crucial when one considers 'emergence'—"as a system becomes more complex, there is an increased likelihood that data based on its elements as studied in isolation cannot be generalized to the system as a whole."/54

It appears that one can find supporting data for either side of the question of whether microwave radiation at low power densities produces harmful effects on the biota; from the position that the central nervous system may be damaged/55, to the possibility that immunological responses may be improved./56 There are also studies which seem to show that physiological adaptation to radiation can result from repeated exposures./57 Part of the lack of consensus may be blamed on the "inadequacies of either technical facilities and measurement skills or insufficient control of the biological specimens and the criteria for biological change," according to Michaelson. The difficulties inherent in an attempt to correct this situation when dealing with complex biological interrelations are many and increase dramatically when investigation moves from the laboratory to the natural environment.

Regulation. The EPA's Office of Radiation Programs was expected to issue guidelines in 1978 for other agencies to use in formulation and enforcement of their own regulations regarding exposure to nonionizing radiation. These have not been forthcoming and EPA is still studying the matter, but it is generally thought to be a low priority item for the Office, which seems to prefer to wait until there is more conclusive scientific evidence on which to base guidelines. Staff members at FCC expressed some frustration at EPA's slowness to act, since they bear the brunt of the occasional controversies which arise.

The more serious risk is that local governments, when faced with active concern by their constituents in a particular situation, may move ahead to regulate microwave radiation. This almost happened in 1978 in New York City. At that time, nine TV broadcasters were using 18 transmitters to broadcast from the Empire State Building tower and the FCC, in preparation for their expected move to the north tower of the new World Trade Building, approved an additional two transmitters./58 The New York City Board of Health proposed an amendment to the City's Health Code (Section 175.125). According to the TV broadcasters, the effect of this regulation would have been:

- a power reduction to 1/30 of that authorized by the FCC;
- a loss of 53% to 60% of the broadcast area;
- 1,327,000 fewer homes served;
- degradation of quality in reception of the remainder.

The present guidance available from the Federal government is an "advisory" from OSHA under its "General Industry Standards and Interpretations" which says that over frequency range from 10MHz to 100,000MHz, the average radiation in 0.1 hour should not exceed 10 milliwatts per square centimeter. The proposed New York Standard would have been 50 microwatts per square centimeter.

EPA, in a letter to the Board of Health, said (July 1978) that it "expects to arrive at a decision on the need for guidance...shortly." The U.S. Department of Health, Education, and Welfare said that, "...it is simply not possible to arbitrarily establish a safety level..." The Department of Defense said that the proposed action was "premature" and that more "dispassionate studies" were needed.

The New York City regulation was tabled. However, it is possible that other local governments may in the future be inclined to take action. The effect of many different local regulations could not only be a barrier to development of particular telematics applications, but more importantly could disrupt national communications systems.

EPA-287 (Cin.)
(4-76)

IMPACTS ON THE TECHNOECONOMY

Earlier parts of this section considered the physical environment and public health and safety, which are central to EPA's mission. This subsection looks primarily at social and economic changes which may occur as a result of telematics. These charges, however, may themselves have impacts on the environment and public health, and it is quite possible that in the long run, these indirect environmental effects of telematics may be far more important than some of the direct effects we have discussed.

Society, its institutions, and people's behavior change in response to new technology; they adapt themselves to make better use of its capabilities. The technoeconomy is a comprehensive concept for the artifacts and interactions of the technology, the economy, and people; the products of this interaction; and the rules and conventions within which things occur.

The technoeconomy therefore includes factories, workers, things produced in factories or in cottages, the harvest of trees and mining of minerals for production of other goods, government regulations which affect technology, and taxes which pay for that regulation. Telematics is itself a part of the technoeconomy and affects and is affected by other parts. Major changes which telematics will bring about in society, which will in turn affect the environment, include:

- the electronics industry;
- decentralization of population and industry;
- work; and,
- the built environment.

The Electronics Industry

The most direct way the development of telematics affects the environment is by means of its own production cycle—i.e., the procurement of raw materials, and the production, use, and disposal of telematics products. The procurement of the requisite raw materials is not notably disruptive of the environment, and none of those presently in use is especially rare or otherwise difficult to obtain. As noted before, the production process involves the use of some toxic chemicals, and is regulated by OSHA. The human health and safety portion of this section highlights some potential hazards to human health in the use of computers and copiers, particularly under conditions of poor ventilation or in a fire. At present, there is no problem about end-of-cycle matters, such as the recovery and recycling of valuable and potentially hazardous parts, or their disposal in other ways, because economic interests encourage safe disposal practices. This may not be the case forever and this possiblity should be watched.

The telematics/electronics sector of American industry is already large and will almost certainly be a major stimulant of economic growth in the future. It is likely to provide major exports, contributing to a favorable balance of trade, and to provide significant employment. Indirectly, this healthy economic growth will benefit the environment because prosperous nations are apt to allocate more resources to environmental protection and improvement than those which are economically depressed. As an industry, telematics/electronics does not appear to be highly polluting. This favorable portrayal of the industry should perhaps be viewed cautiously; by the nature of the industry, it is likely to be a leader in automation. As new generations of industrial robots are developed, they are likely to have capabilities, such as "sight", which will enable them to replace workers on assembly lines. Reduction of this kind of employment can have severe impacts on the local economy in many areas of the country.

Decentralization

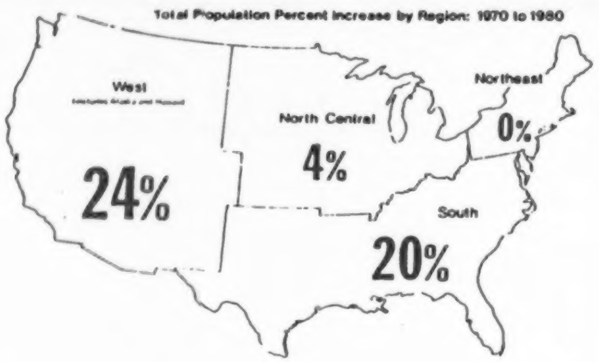
As noted in Section 4, decentralization of population and industry has been proceeding for about two decades. Decentralization has several aspects: the movement away from the heavily populated Northeast, toward the West and the South; movement from large cities to smaller cities, from metropolitan areas to non-metropolitan counties, and from urban to rural areas; the movement of commercial activities from central business districts to suburban malls and of industry from manufacturing cities to industrial parks and rural locations, and finally, the tendency for individuals to work at home rather than traveling to work, already discussed under "transportation/communication trade-offs".

The movement toward the Sunbelt became strong during the decade 1970-1980. During this period, U.S. population increased by 23.2 million people, or 10.2%. About 90% of this growth was in the South and West. The western region grew by 24% and the South by 20%, while the Northeast showed no growth (see Exhibit 5-5). Nevada, Arizona, Florida, Wyoming, and Utah all had growth rates of more than one-third (38% to 63%)./59 The reversal of the long trend toward greater urbanization was also striking, with non-metropolitan counties for the first time growing faster than metropolitan counties.

There are many reasons for this shift. The older mass movements—of farm families to the cities, and of southern Blacks to the North—had about run their course. Farm workers and their families declined in numbers from 30.5 million in 1935 (25% of total population) to 8 million in 1978 (3.7% of total population), as farm employment dropped from 12.5 million to 3.9 million./60 The wellsprings of this migration had about dried up. The shift of Blacks from South to North had also continued for several decades.

In part, people are seemingly *pushed* from larger cities by pollution, congestion, crowded housing, fear of crime, the perception of school deterioration, and the higher cost of living; and *drawn* to suburban and rural areas by government housing policy (veterans' mortgages) and mass tract development, which lowered housing costs. The movement toward suburbia, however, began early in the century as public transportation and workers' improved wages brought a house and land within economic reach for the masses. Industry began to move outward in the 1950s and 1960s, choosing to replace aging factories in suburban and rural rather than traditional urban locations because of cheaper land, lower taxes, lower prevailing labor rates, improved highways, and special incentives offered by states and local governments eager to attract

EXHIBIT 5-5: MAP—TOTAL POPULATION INCREASE BY REGION, 1970 to 1980



Source: DUA Labs Register, No. 7, Spring 1981.

employers. With better employment opportunities at home, fewer young people have been forced to move to the northern cities. Overall, the most important factor may have been that increasing affluence allowed more people to exercise their locational preference, which in America has seemingly always been biased toward small town living. In the last decade, the increased costs of home heating have added further stimulation toward moving south and west, especially for the increasing numbers of the elderly and retired.

In these movements, there is no evidence that telecommunications or telematics has been a primary driver. However, by reducing the barriers of distance and time (which in industry, and also in preserving family and friendship ties, directly translate into economic costs), telematics permits and facilitates a decision to move. In particular, advances in telematics contributed strongly to increasing efficiency of transportation, which probably was a primary driver in the relocation of industrial and commercial activities. There is as yet little indication as to how far these movements will go. Redistribution of people and activities could follow the familiar S-shaped curve of technology-substitution; but there is little evidence yet for the eventual shape of this trend. Clearly it will not approach its outer theoretical limit of even distribution of people across the land, which would mean about 65 people per square mile if it occurred today, or one person for every 10 acres.

One major impact of population redistribution is political change. In the reapportionment which follows each census, western states and Florida will gain votes, and some suburban and rural areas in each state will gain at the expense of cities. This is generally expected to increase the strength of what has been called the "Sagebrush Revolution," meaning a reassertion of State rights over public lands and natural resources and a diminution of Federal control. It should be noted, however, that while some western and southern states have maintained that some environmental regulations, such as air pollution standards, have been excessively stringent and rigid in the

EPA-287 (Cin.)
(4-76)

context of regional differences, the western population also is intensely concerned about water availability and quality, protection of beaches, coastal areas, fisheries, and fragile ecologies. It is likely that some priorities with regard to the environment may change; it is also likely that there will be sharply increased controversy and conflict over the competing demands for resource development and environmental protection and between the interests involved in multiple use of lands.

The implications of decentralization for the environment are also not clear cut or undimensional. Decentralization of population and industry will certainly mean differences in the kind of stress imposed on the environment. Whether or not it will reduce the stress overall is less certain. The population will continue to expand for several decades at least so that a shift in proportional distribution of population does not necessarily mean a reduction from present levels in most areas. Very large concentrations of population and industry tend to impose on the environment insults which may exceed local carrying capacity or regenerative capability, and concentrations of pollutants may be necessary before there is a significant threat to public health. Decentralization may therefore relieve or prevent some acute environmental problems. This is the strategy advocated by adherents to the appropriate technology and "small is beautiful" movements. Lower concentrations of populations allow the utilities, the public service infrastructure, and the industries which employ and serve them, to be smaller in scale and thus to inflict a much smaller volume of pollutants on the immediate environment.

However, "dilution is not the solution to pollution," according to another line of thought. Many widely dispersed sources of pollutants are more difficult and more costly to monitor and control. Some forms of treatment—sophisticated emission control technology and tertiary waste treatment for example—may be too costly for small plants and small population centers. A more dispersed population is likely to intrude on presently pristine areas and on fragile environments such as arid lands. There might, overall, be far less undeveloped land (even though urban land would be less intensively developed) to provide regenerative capacity. Use of energy might be less efficient, given the expanded transportation network which would develop.

If decentralization proceeds (and there are some signs that it may not, such as the re-urbanization or gentrification which is developing in some cities), EPA will have to develop different strategies for accomplishing the same objectives even if there is not a political reallocation of responsibility between State and Federal levels of government. Telematics again can be a facilitator, reducing some of the costs and difficulties of dispersed environmental management. Pollution monitoring, measurement, and control on a highly dispersed basis is not impossible; with appropriate telematics it may become highly efficient. Alternatively, telematics could allow a centralized data bank and information system to provide support services for many institutionally separate environmental agencies.

A decentralized population, with substantial numbers of people working at home or in neighborhood work centers, would also have important implications for the environment. First, it would throw the present system of taxing businesses into confusion. If a company has its workers scattered across many

EPA-287 (Cin.)
(4-76)

communities, something telematics permits it to do, why should it pay all of its taxes to the jurisdiction where its headquarters happens to be and none to the others where the workers are located? This ties in with similar questions of allocating responsibility for pollution now that telematic monitoring allows us to trace it. What about pollution which is primarily felt far away from its geographic source? If increasing numbers of functions which have traditionally been connected with political jurisdictions become geographically detachable, what is the meaning of political jurisdiction?

Another type of impact which may result from telematics-supported decentralization of the population and local workplaces is the type of investment which people may make in their communities. Citizens are likely to become more involved in municipal affairs if there is no separation between the community in which they work and that in which they live. They may become more demanding consumers of government services if they are more dependent on them. People are also likely to become more socially dependent on their neighbors if there is no alternative community in the distant workplace. This is consonant with on-going trends toward local involvement, regional interests, interest in community building, and smallness of scale. If it should take hold, it would signal a reversal in the 20th Century technological trends in which technology has the net effect of socially separating and isolating people while making them, through their mutual dependence on the technology, more unobtrusively interdependent.

The Management Of Industry

Decentralization of the workplace would require changes in the management of industry. This would most obviously affect knowledge workers, but industrial manufacturing processes no longer need to be centralized either. There would be both a difference which comes from managing a geographically dispersed work force, and a difference in managing a work force which is a conglomeration of independent agents rather than a salaried team. There may in fact be a resurgence of cottage industry. This could raise all the equity-related issues which were thought to have been on the road to solution over the last century or so: child labor; discrimination on the basis of race, sex, religion, and age; standards of pay; unionization; etc. Workplace decentralization would thus throw both management and labor into a very different orientation.

Decentralization of the workplace is also likely to bring into focus the independence of geography and power. The new capability of telematics which permits the physically decentralized organization of work also enables a sharp increase in the centralization of power. This is so despite the tendency of complexity to lead to decentralization, because one of the special new capabilities of telematics is the control of complexity. It is such a major shift that there is quite likely to be a period of discontinuity and disruption as people adjust.

Management issues are only one aspect of impending change for business and industry. The nature of the work to be done will also change a great deal.

EPA-287 (Cin.)
(4-76)

Industrial sector. Few areas will have greater consequences for managers than the increased use of robots. It will affect investment planning, production capabilities, and labor relations, while it progressively changes the physical nature of the workplace.

The concept of robots performing manufacturing tasks is hardly new, but several emerging factors have made this an increasingly important subject for discussion and analysis.

U.S. industry, hard hit by inflation in labor, materials, energy, regulatory costs, and capital costs, and facing ever tougher overseas competition, has recognized the need to revitalize operations. Output must increase as production costs decrease. Nowhere is this more evident than in the U.S. automobile industry, which is now the largest market for robots.

The development of the microprocessor has been the key to bringing robotics into full swing, allowing machinery to go beyond simple automatic, repetitive movement to performing more complex tasks. More important, the computer chip, in conjunction with other information processing and transmission capabilities, has allowed development of robots which can be quickly and easily re-programmed.

One example of the adoption of this flexible manufacturing system is the factory of Normalair-Garrett in Crewkerne, England./61 The plant makes and assembles parts for an airplane bomb release system containing some 100 parts. On the basis of instructions from the main computer, it is possible for the robots to stop machining a particular piece and begin working on another.

The implications of this are enormous when one considers that for many firms it is not possible to use conventional automated machinery which can only be used in large production runs. Peter Marsh of *New Scientist* notes that 75% of all metal parts made in Britain are produced in batches of less than 50./62 Thus, with the aid of robotics, it is possible to have an automatic production system which promises great elasticity of supply, by allowing precise control of inventory. For managerial purposes, this is very important: response to buyers can be more timely, energy inputs can be used more efficiently, and planning in general can be made more precise.

It is possible that flexible manufacturing systems will enable small companies who might otherwise be unable to do so, to compete with larger, conventionally equipped ones. Certainly there will be some degree of increased ability to enter a field and hope of finding a niche through aggressive marketing.

This is true in the United States as well, where *Time* reports that, "60% of U.S. manufacturing is done in batches too small for assembly lines...and it is estimated that they (robots) can reduce costs in small-lot manufacturing by 80%-90%."/63

With these figures in mind, it is reasonable to assume a dramatic increase in robotics, and in the larger sphere of computer-assisted design and computer-assisted manufacturing (CAD/CAM). An indicator of this is the fact that "more than half a dozen new suppliers (of robots) have sprouted up in the past two years, including three so far this year (1980)."/64

There are many areas where robots will be able to perform tasks beyond human capabilities. Humans come in a fairly standard shape and a rather narrow range of sizes. Robots, on the other hand, may be designed to fit a task requirement, such as pipeline inspection, or movement of heavy objects in a confined space at awkward angles. Likewise, robots can function in a much wider range of environments than human workers, for virtually any length of time, and with a negligible rate of error. For example, Westinghouse uses a robot in the making of tungsten light bulb filaments, a process involving the stretching of 21-inch rods to 37 inches, with exactly a .467-inch diameter. As part of this, the rods must be placed in a 3200°F furnace. Before the robot, this job took three workers, whose performance understandably deteriorated toward the end of the day. The robot "does it flawlessly for about 16 to 24 hours a day. It will pay for itself in 2½ years."/65 The further refinement of sight and touch capabilities will make it possible for robots to perform complex assembly tasks that currently can only be done by human workers.

It is not so much the complexity of the assembly process which makes the robots now on-line incapable of performing more complex tasks. Rather, the problems are in such areas as the robot's knowing when a bolt is tight enough, and the need to have parts positioned and aligned perfectly by operators, since the robot must function blindly. Digitalization of video images and the development of "tactile" abilities are already far advanced, although there are still bugs to be ironed out and costs are high. Renault, the French automaker, has a robot which can identify and discriminate among 200 parts presented on a conveyer, and Draper Labs has developed a robot "hand" which is sensitive enough to jiggle a bolt into place./66

A key question for management and workers surrounding the robotics discussion is that of social costs, or the impact of CAD/CAM on labor. Organized labor has not yet marshalled its forces against this technology, at least partly because many applications have been to tasks that humans cannot, or will not, perform. In addition, unions are generally more concerned with the present rather than the future, and have thus far regarded robotics as acceptable so long as the substitutions are linked to normal attrition rates and compensation is not decreased. The fact that robots themselves must be maintained and supplied the parts with which they are working seems to allay the fears of many that there will be a net decrease in employment. Rather, a set of new types of jobs, and more of them, will be created according to, among others, Raj Reddy of Carnegie-Mellon University./67

Perhaps this is true, but at this time we must deal with projections; and not all of them are optimistic. Figures cited earlier show that there are strong incentives for firms to replace workers, especially those who are less skilled. Normalair-Garrett, for example, has projected that, "each person can, with the new machinery, make things worth five times as much as his counterpart in a conventional workshop."/68 For those companies that retain conventional systems, there is danger that their automated competition will force them into bankruptcy, resulting in layoffs. Even if one assumes that, in the long run, there will be no overall loss of jobs, the transition period will be a difficult one for many. Who will pay for retraining programs? What will happen when union funds are not able to support the affected workers? What types of changes will take place in union structures as a result of changes in constituency? It is in the interests of organized labor to consider these questions now if they are to act effectively in the robotics-oriented future.

There were estimated to be about 1500 industrial robots in use in the U.S. in 1977 (current figures are not available; many companies guard this information as proprietary)./69 Projections of robotics sales have been, over the last decade, over-optimistic in hindsight, because capital investment was slowed by inflation. At present, with the new interest in re-capitalization for greater productivity, robotics projections appear to be converging at about 70,000 in use by 1990. The investment firm of Bache Halsey Stuart Shields, Inc. estimates that robotics in use by 1990 could be anywhere between 23,000 and 70,000, unless (as has been widely rumored) three large telematics producers move into the market, in which case the number may go as high as 200,000./70

Industrial robots are now performing the following jobs:

- spot welding
- paint spraying
- handling and moving materials
- bending, cutting, heating, quenching, and assembling materials and parts
- stamp press loading
- die cast unloading and trimming
- hot forge press loading
- die transfer
- drop hammer forging
- glassware handling and transfer
- brick hacking and setting
- bobbin doffing

Future generations of robots with visual capability and other advanced capabilitities will be able to handle many more manufacturing operations. In these jobs, each robot can replace at least three workers (operating three shifts a day) and has a lifetime of five to eight years. They are considered a cost effective investment if they replace two workers and last five years./71

Business Week magazine reported this year that General Electric plans to replace 2000 workers with robots soon and will eventually replace one-third of their 27,000 assemblers./72 We estimate that there were, in 1977, approximately 2.7 million jobs in the U.S. which could have been filled by robots. According to a Bureau of Labor Statistics projection, about 1.6 million new blue collar jobs will be created by 1990 at expected economic growth rates (this projection, made in 1978, is probably no longer considered valid, but we will use it for rough estimates)./73 If this was correct, other conditions remaining the same, the introduction of 70,000 robots would reduce these new jobs by 13%, and 200,000 robots by 38%. Thus, industrial robots have the potential of severely restraining the growth of new employment even if not reducing the total number of jobs.

Whether or not industrial robotics will reach this level of use by 1990 depends on a number of factors, of which interest rates and their effect on capital investment are one. Managers are usually motivated to switch to robots for appropriate tasks by rising labor costs, high labor turnover, unacceptable error rates, and the rising costs of occupational safety and health regulations. If there is competition for available jobs, holding labor costs down, robots would still be attractive for tedious, monotonous, but exacting jobs where error rates mount toward the end of a shift, and absenteeism and high turnover is a problem. Robots are also particularly attractive for tasks which are hazardous or require special protection for workers.

This suggests another possible indirect impact of robotics. If displacement by robots is perceived as a risk, workers and their unions may be much less inclined to identify and protest hazardous conditions and demand appropriate protection. The existence of robots as an alternative to human labor, therefore, could serve to undercut the movement for improved occupational safety and health.

The model described in Section 2 suggests that a new technology at first substitutes for older technologies, in this case, for human labor; this causes the host institution to undergo internal changes to adjust to the new technology; then the technology's new capabilities allow the development of new activities and the achievement of new objectives. We have so far spoken only of the initial substitution of robots for human workers. However, robots are likely to be adopted in conjunction with (or to encourage the parallel adoption of) "flexible manufacturing systems" and "group technology." With these systems, the factory floor is rearranged or redesigned so that industrial robots are surrounded by their materials and tools, forming cells, and parts are routed by computers from cell to cell in a sequence determined by the work to be done on them. This transformation of the workplace not only calls for fewer human production workers, but in fact makes the factory floor an inhospitable place for humans—it is designed to fit the needs of machines and not workers. Thus, the adoption of additional robots encourages physical adjustments which stimulates the adoption of additional robots or other forms of automation. For these reasons, our analysis indicates that under economic conditions which would make a significant level of capital investment possible, adoption of robotics would be likely to proceed very rapidly.

Such redesigned factories would be planned for maximum efficiency in use of materials and energy, and would be very likely less polluting than older factories built when such considerations were given less attention. On the other hand, if adoption of robotics proceeds very rapidly, there may be enough

EPA-287 (Cin.)
(4-76)

displacement of workers to bring about social conflict and a strong reaction against them.

Coming generations of robots, with greatly expanded capabilities, will provide us with opportunities which are now beyond reach. Robots can be designed to function in environments in which humans cannot intrude, or can venture only with such elaborate support systems that their ability to do anything useful is sharply curtailed. Such hostile environments include, for example, outer space, the deep ocean, deep mines, or volcanic interiors. Robots therefore could eventually be designed for exploration, mining, space manufacturing, rescue, or specimen gathering, extending the reach of humans beyond their own limitations. Such activities could well extend our knowledge of environmental relationships and our ability to attack environmental problems where humans can live; but unless carefully planned and monitored, they could conceivably also extend humanity's pollutants into new areas and poison the source of environmental resources.

Agriculture. Agriculture is another sector whose organizations is likely to change radically with increased application of telematics. Two agricultural revolutions in this century—mechanization and chemicals—by analogy suggest the magnitude of impacts which could result from telematics. Only a few of the possible applications have been developed so far. Yet almost every aspect of agriculture offers opportunities for dramatic improvement with the application of telematics. Many farmers already use computers to keep their accounts and records, and there are sophisticated information systems to predict and interpret weather in terms of the type and location of a farm. With satellite sensors and computerized models, the science of meteorology is making enormous progress. We can expect earlier, more accurate, and location-specific forecasts.

Farmers and commodity markets will be affected by satellite prediction of crop yields well in advance of harvest. With computerized models and specialized information systems, the farmer can determine the best time for harvesting produce, selling livestock, or the best mix of crops to raise, or feeds to offer the animals. Virtually all of the applications of telematics to human health have analogs on the farm, from implanted monitors in livestock, to veterinary care, to better control of data.

As more intensive use is made of telematics in agriculture, we can also expect significant change in many patterns of social interaction, from the exchange of commodities to migrant labor patterns.

This kind of control will enhance some of the trends now characteristic of agriculture. It is already a very high overhead business, and telematics will make it more so. It now requires a deep and broad understanding of the technoeconomy to succeed as a farmer, and telematics will raise the knowledge and integration stakes. It will facilitate agribusiness on an even grander scale, and make an extremely competitive, high-stakes enterprise more so. It will become more uncertain in that one will need to have the best information in order to compete, and that will involve even higher overhead.

At the same time, small family farms are likely to be even more hard pressed than now to compete with larger enterprises. However, if present trends continue, we may see a resurgence of the quasi-homestead lifestyle, in which a family depends in part on homegrown produce and animal products, and in part on the cash economy./74

Mining and fishing. As extractive industries, mining and fishing stand beside agriculture in the technoeconomy. The pattern of their use of telematics and its implications for the environment closely resemble the applications of telematics to natural resource management as described earlier in the selection on the biota. Satellite-based sensors and computerized pattern recognition procedures show the location of specific mineral resources in the earth. Similar procedures can locate the most likely patches of ocean for fishing certain species. From the environmental perspective, the impact is more effective management of the resource: fish are not depleted, and minerals may be extracted with little disturbance to the biota.

Knowledge industries. Knowledge industries/75 are likely to undergo equally profound changes as a result of the application of telematics. While agriculture and manufacturing have been automated for some time, information businesses are automating right now. This implies profound change for industries which are built around the matching of questions and answers, such as travel agencies, insurance companies, investment brokers, and retail merchandising, which have traditionally been labor intensive.

Some of them may die out as a result. All are built around the sale of scarce information which they collect, screen, and synthesize for the buyer. With the same raw information commonly available via teletex, enough people may choose to do their own screening and synthesis to sharply reduce the demand for such services. While a home computer and teletex is considered a luxury item today, in 20 years, personal service may be the luxury.

Clerical work will become more technical, as workers operate word processors, automated filing and indexing systems, and do their own programing.

The amount of capital which is being invested in the industries today for automation is very large indeed. We must understand the effects which their use will have on this sector lest we unwittingly build a system which is adversarial and divided within itself.

Workers

There are three clusters of issues related to telematics for workers. First, there are a number of issues relating to the changing skill requirements. Telematics will probably bring about a mismatch in the array of jobs to be done compared to the array of skills among the work force. New jobs will be created, and some old ones will no longer need to be done. The choice will become retraining or job loss for many. The traditional distinction between blue and white collar work will vanish. There is also likely to be an increased demand for workers in such jobs as electronics maintenance. While some unskilled jobs will probably never be automated, especially personal service work, the net demand for unskilled labor is likely to decrease.

Job loss will be uneven. The loss of jobs will primarily be due to the substitution by telematics. For example, it has been estimated that 128,000 American auto workers will lose their jobs by 1985 due to manufacturers' investments in increasingly sophisticated and adaptable automated equipment. /76 The creation of new jobs, conversely, will be in part in producing and selling telematics, and in part the result of developing the new capabilities which are inherent in telematics. Whether or not there will be a net loss of jobs remains to be seen. Recent studies by the Worldwatch Institute/77 and the ILO/78 predict a net loss of demand for workers. Peter Marsh has put the transition to telematics into a very long-range historical context, and concludes that while adjustments always compensated for labor displacement before, this time it may well not be so./79 For nations like Norway, where there is a perennial shortage of labor, the semi-official policy decision has been made to back CAD/CAM as the only way to increase industrial output./80 On the other hand, many people do confidently predict a net gain in jobs. Some new jobs will, no doubt, be created as the new capabilities of telematics are exploited.

Telematics will affect the power relationship between workers and management in several ways. First, it will be far more difficult to organize and maintain labor unions if the work force becomes physically decentralized. Also, increased competition for jobs may tend to hold wages down, and decrease both the incentive to organize and the inducements to adopt telematics. By the same token, management supervision will face problems from decentralization as well. Flexible manufacturing can make businesses more vulnerable to strikes because of reduced inventories. Thus, management is likely to monitor the mood of the work force more closely, and plan their inventories accordingly. This tactic could lead workers to engage in more wildcat strikes. Small manufacturers may see some benefit, in that case, in organizing mutual aid societies to protect themselves against strikes.

An interesting question in relation to organized labor is retraining of workers displaced by telematics. Who will pay for it? Unions? Employers? The Federal government?

Certain groups of workers may be more affected by these telematics-related changes than others. Workers in the telematics industry itself will be in a strong position. There is continuing controversy about the impacts on postal service workers./81 We have already discussed the cloudy outlook for manufacturing and knowledge industry workers.

The Built Environment

There is a strong possibility that telematics technologies will be applied to the redesign of city structures and the offices within them. The land use patterns of urban areas have developed in accordance with the proximity-related needs of the many groups within them. Just as the streetcar changed workplace/home proximity requirements, so will telematics be a facilitator in changed use patterns.

As the telematic office becomes an accomplished fact, there will be a need for planners and managers to design workspace in line with the specific

EPA-287 (Cin.)
(4-76)

requirements and capabilities of the technologies. In light of the recent findings on the effects of ozone emitted by copiers, it is necessary to design adequate ventilation into their site within the office. Users of video display terminals must consider a number of site-related requirements in order to avoid stressed, uncomfortable, and sore-eyed operators. Telematics will accelerate a need for an environment planned around technology. This will be accomplished, at least in part, by using the machines' own capability to do the designing.

SOCIAL DISCONTINUITIES

The biota, human health, and the technoeconomy are the foci of EPA's interests. There are three other sets of potential impacts which are so broad that they cut across the structures of society including the biota, health and safety, and the technoeconomy. Because they are so general, they could be called meta-impacts. They are potential forces of societal discontinuities on a grand scale. If these impacts should come to pass, they would vitiate many other benefits and trivialize the other problems associated with telematics.

The first of these is the possible fragility of a telematics-intense society. Any technology on which society becomes broadly and intimately dependent for normal functioning presents a critical vulnerability of that society. If that technology fails on a large scale, society is disrupted, e.g.,as by a regional blackout. The technology failure could be the result of natural disaster, hostile actions, interruption of necessary supplies, or merely the cumulative results of a great many small component failures. The GAO has investigated this with regional ADP systems./82

A telematics-intense society is vulnerable to terrorism. Another fragility is the susceptibility of our electric power supply to fluctuations, due to suddenly increased demand or shortages of fuel (blackouts and brownouts). Telematics are dependent on a power supply which is interruptible through accident, hostile intent, or its own systems failures. A third type of fragility is the difficulty of maintaining and repairing extremely precise, complex, small equipment. There could be, under some occasions, a shortage of people who are skilled in such maintenance. A fourth, newly recognized fragility is susceptibility to electromagnetic pulses. An electromagnetic pulse would be a by-product of high-altitude nuclear explosions that would blanket huge areas of the world with peak fields of 50,000 volts per meter. Defense strategists suggest that a single detonation 200 miles above Nebraska would knock out unprotected communications equipment all across the United States./83 A very large part of our telecommunications systems, including the Bell System and most of our military networks, are unprotected. There appears to be little disagreement about this vulnerability, should an external or internal enemy succeed in setting off such a detonation; disagreement is only about whether and how the military authorities are prepared to cope with it.

The second meta-impact is technical. There is widespread agreement regarding the critical need to develop structures for the synthesis of information, and the analogous critical need to develop more sophisticated methods of programming which will exploit the technical capabilities of presently

EPA-287 (Cin.)
(4-76)

developed machines. A third technical structure which needs immediate attention is the system of laws and regulations. They need to be adapted to telematics and the new problems of regulation which it raises. If this intellectural inventing is not done, the telematics-intense society cannot be sustained.

Finally, there is a political meta-impact. It comprises a set of policy stances toward the distribution of information. While there is much talk about the economics of information, the fact is that information is not a commodity like any other, and that ordinary approaches to establishing its price or value are not used and are not likely to be used. A new approach must be developed. The question of access to information is related. Is it a right? Is it a commodity? Who will have access to what information and who will not? These questions sound deceptively simple, but they are profound. If they are not seriously addressed soon at the highest levels of public authority, then it is likely that telematics will prove to be a social time bomb. Rather than a society of haves and have-nots it could become a society of know and know-nots.

WHICH IMPACTS ARE "MOST IMPORTANT"? CRITERIA FOR SORTING

The sweep of the potential impacts already identified argues for some sorting out to help set priorities for further study, and for other actions. The assessment team developed and used several sorting systems or criteria sets discussed below. In addition, two workshops were held; participants, who included government officials, industry representatives, and other experts on telematics, and representatives of groups of potentially affected parties, vigorously discussed with the team appropriate criteria for evaluating impacts.

Criteria for meeting EPA's research objectives. The widespread conclusions in the scholarly literature and among those who worked on this project are that the long-term consequences of telematics for American and world society are as profound as the effects of the Industrial Revolution. Against that panoramic sweep of revolutionary change, the interests of EPA are muted in at least two ways. They are muted in the general discussion of impacts and consequences of telematics, and they are muted in the relevancy of the sorting criteria to EPA's mission. In this section, the focus is directly on criteria for selecting projects to meet the long-term early warning objectives of the Office of Strategic Assessments and Special Studies of EPA.

The Environmental Protection Agency, an organizational product of the problems of the 1960s and early 1970s, and its legal charge, its organizational structure, its staff ambience, its orientation toward the Federal system, and its social role, are framed around problems that matured over the last three decades. Insofar as telematics represents a revolutionary family of technologies and social developments, one could expect a mismatch between EPA's organizational categories and what will consistently prove to be important the future.

One can expect substantial dissonance between the problems that will become increasingly important and the present structure of the agency. By analogy, the same argument holds at the next higher level of abstraction in regard to how the total responsibility for dealing with society's problems is divided up among Federal agencies. The functions dealing with occupational health and safety, biomedical developments, educational needs and opportunities, and so on, will all be dislocated by the pervasive impacts of telematics technology. In each case, there will be dissonance between the new problems and opportunities and the established governmental structure.

A four-stage approach used to identify the most fruitful areas for EPA's long-term research includes:

- A taxonomy of causes of future environmental problems presented in EPA's Research Outlook 1980 in the chapter on "Anticipating Future Environmental Problems."
- A list of criteria emphasizing scope, scale, importance, imminence, and uncertainty over the opportunities or problems, i.e., the benefits or the costs of the telematics technology to society.
- Attention to government's role, especially where government's failure to act will lead to either lost opportunities or the fulmination of undesirable environmental impacts.
- Direct attention to EPA's established statutory role in research development monitoring, problem identification, and information transfer, as well as attention to such matters as researchability.

These four points are discussed in order.

The causes of future environmental problems. Exhibit 5-6, drawn from the chapter on "Anticipating Future Environmental Problems" in Research Outlook 1980, identifies eight generic causes of the environmental problems which have come to be so important in the recent decades. Changes in social values often change behavior or social objectives in a way to create or aggravate a problem. New knowledge can raise our concern and intention about what had otherwise been ignored. Population and economic growth are overwhelmingly dominant drivers in drains on natural resources, production of waste, and the consumption of energy. Frequently, the neglect to the end of a life cycle of an industrial or commercial process leads to environmental problems. Almost all solid waste disposal problems are of this sort. Acid rain also illustrates that more intensive use of material can create a problem. One might anticipate, if we went to the use of more exotic materials in an electric automobile fleet, new or uncommon materials could become widely dispersed. Scale—that is, the simple volume or size of a facility—can create special problems, often by exceeding carrying capacity of the local environment. And finally, new technologies themselves may create problems which we are slow to catch on to, for example, DDT's side effects.

These points are displayed in some detail in Exhibit 5-7. When used as first criteria, they raise the question as to whether the anticipated impact relates to any of these generic causes. If they do, they are more likely,

EPA-287 (Cin.)
(4-76)

EXHIBIT 5-6: CLASSES AND CAUSES OF FUTURE ENVIRONMENTAL PROBLEMS

Cause of Problem	Potential Problem	Description	Class of Problem
Changes in social values.	Indoor pollution from domestic toxic materials, such as carbon monoxide and accumulation of offensive odors.	Energy conservation in space heating results in substantially lower rates of air turnover.	Known problem, unknown scope.
New knowledge.	Removing or adding trace materials in the human, animal, and plant environments.	Growing knowledge or the role of trace materials, and increasingly sensitive instruments for their detection and measurement may call for new measures to regulate trace materials.	Known problem, unknown scope.
Population and economic growth.	Irreversible melting of the polar ice cap.	If the greenhouse effect from carbon dioxide in the atmosphere, from expanded use of organic fuel, is a real threat the heat could melt the ice at the poles and flood most coastal areas.	Unknown problem, potentially discernible.
Neglect of life cycle.	Clean up after a nuclear event or reactor decommissioning.	We may be unprepared to clean up after a nuclear power plant accident or a limited nuclear exchange.	Known problem, unknown scope.
Neglect of life cycle.	Dam silting.	A major spate of contemporary dam building occurred during the second quarter of the 20th century. Therefore, during the first part of the next century silting may become a world-wide problem. Only two of the 25 largest dams in the world were completed before 1955 (1932 and 1940).	Known problem, unknown scope.
More intensive intensive use.	New environmental pollution from cadmium, lead, sulfur, zinc, nickel, and other materials.	It is plausible that electric cars may develop into a substantial fraction of the auto fleet. They would have to use some kind of battery storage system based on lead, mercury, cadmium, sulfur, zinc, nickel, or other materials not now generally deployed in the environment in large quantities.	Contingent problems.

Source: "Anticipating Future Environmental Problems," Research Outlook 1980, U.S. Environmental Protection Agency, Research & Development 600/9 80-006, February 1980, pp. 189-190.

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EXHIBIT 5-6: CLASSES AND CAUSES OF FUTURE ENVIRONMENTAL PROBLEMS (cont'd)

Cause of Problem	Potential Problem	Description	Class of Problem
More intensive use.	Rural land pollution.	The general lack of land use control in rural America coupled with the increasing rate of introducing new technologies into rural America will lead to greater waste disposal, land pollution and aesthetic problems.	Known problem, unknown scope.
Scale.	Destruction of ancient and modern architectural and structural artifacts.	As industrialization proceeds in the Third World, at current low standards of pollution control, structural artifacts and art work, such as the Taj Mahal, will undergo serious deterioration.	Known problem, unknown scope.
Neglect of life cycle.	Urban vermin.	Rats, roaches, and other vermin in urban areas are increasingly resistant to control agencies, while the use of control agents is being more restricted. Aside from the offensive nature of vermin, they are disease vectors.	Known problem, unknown scope.
Neglect of life cycle and scale.	Sulfur wastes.	The growing use of sulfur-rich fossil fuels will, under present regulations, lead to the accumulation of large quantities of sulfur from de-sulfurization. Disposal presents problems.	Known problem, unknown scope.
New technology.	Ocean pollution from industrial pollution.	With the large-scale mining of the seabed resources possible, we find that we have relatively little understanding of the effects of the oceanic equivalent of mine tailings. Mine operations are likely to raise large quantities of trace materials, as well as vast quantities of particulates, into the life zones of the ocean.	Contingent problem.

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EPA-287 (Cin.) (4-76)

EXHIBIT 5-7: BASIC CAUSES OF FUTURE ENVIRONMENTAL PROBLEMS

A. Population growth

Increased demand for:

- Food
- Shelter
- Energy
- Goods
- Raw materials

Increased:

- Congestion
- Waste production

B. Economic growth

Increased demand for:

- Food
- Shelter
- Energy
- Goods
- Raw materials

Increased:

- Congestion
- Waste production
- Industrial growth

C. Changing social values

D. New knowledge of:

- Causes
- Effects
- Remedies

E. Neglect of life cycle of:

- Goods and materials
- Processes

F. New technologies

G. Systems vulnerabilities

H. Scale

I. More intensive use of resources and facilities

than otherwise, to enhance or diminish adverse or desirable environmental outcomes. If an impact is not related to one of these causes, or if some special argument cannot be made on its behalf, it is not likely to become a major environmental benefit or cost.

With regard to each of these causes and each of the impacts, we kept in mind the EPA interest in effects on the natural environment—the biota and the ecology—human health and safety, and the technoeconomy, i.e., the man-made environment.

Importance criterion. Having done some sorting organization at the above stage, one would then move on to using the following short list of criteria which define the importance of the impacts under consideration. Whether good or bad, will they:

- affect large or small numbers of people,
- affect identifiable groups differently,
- be irreversible in effect,
- be intense or diffuse,

- be transitional or more long lasting,
- be incremental or precipitous,
- be certain in effects,
- be specific to a certain environmental interest:
  - human physical or mental health,
  - air
  - water
  - solid waste
  - noise
  - biota
  - aesthetics
- affect major infrastructure or resources such as:
  - natural resources
  - renewable resources
  - the work force
  - industrial processes
  - the national security system
  - the national institutions
  - cities
  - agriculture
  - rural life
- have impacts on the technoeconomic structure, particularly:
  - productivity
  - the location of physical facilities
  - vulnerability of social systems
  - vulnerability of technological systems
  - control or manageability of complex systems
- provide or generate new information or deliver a capability for understanding environmental effects.

Impacts may be sorted by the above criteria, using as summations of judgments, scalings from 1-10. Or one might just develop an essayistic analysis incorporating the above points.

Government's role. Recognizing that we are talking about long-term effects and major outcomes, we see that the government role on these long-term matters should be driven by two questions. Will the failure to act be highly likely to cause:

- an undesirable outcome?
- a potential social benefit to be lost?

EPA's role. Finally, a sort along the questions of EPA's direct role should use criteria such as:

- Is the problem unequivocally outside EPA's mission?
- Is the issue tractable by EPA's major forms of action?
- Is new knowledge likely to inform those actions?
- Can that new knowledge be related to specific EPA R&D and information activities such as:
  - research
  - development
  - monitoring
  - evaluation
  - public information
  - knowledge transfer
  - constituency building, inside and outside the government.

This system of sorting is likely to lead EPA's research program to concentrate on new developments and second order impacts and consequences, and to soft-pedal research in those effects which are only marginal additions to existing or already known problems, or which will at worst have self-limiting or only highly localized impacts.

SECTION 6

ISSUES AND STAKEHOLDERS

Major issues with regard to telematics and environmental protection are: what role should government play in telematics development? How will latent environmental problems be identified? How will public concerns be resolved? This section identifies major stakeholders and their active interests. Industry, government agencies, and special affected groups are discussed. None have an economic, institutional, or social self-interest or a definite legislative mandate which assures that environmental problems will be identified for early attention, and that environmental benefits will be fully realized. EPA can fulfill this function, but it will have to identify and understand its latent constituency and provide it with needed information.

A most basic issue with regard to telematics in the U.S. is: what role should government play in its development? Currently there is a movement toward deregulation or reducing the Federal governmental presence in many spheres of activity; and the present Administration has enunciated a policy of leaving technology development to the private sector. As discussed in the final portion of this section, this is a change in the long-standing situation in at least one part of the telematics industries, telecommunications, where until recently major actors enjoyed their position as regulated and protected monopolies.

A closely related issue is: how will public concerns about telematics—especially environmental, health, and safety concerns—be resolved, and how could latent problems be identified in a timely manner, if there is no new Federal responsibility with regard to telematics? There are indicators that local governments may act with regard to some concerns if the Federal government chooses not to act, and in a manner which would be unnecessarily destructive of the public benefits promised by future telematics development.

This section is concerned with stakeholders, potentially affected parties, issues which will affect the speed with which telematics matures, and the ways in which environmental and health issues related to telematics are likely to emerge and to be defined.

Stakeholders are the people, organizations, and institutions that have a direct and strong interest in the future development of a technology. The most visible stakeholder often has explicit expectations of profit and loss as a result of the market performance of the technologies. Government agency stakeholders have a legislated and limited responsibility for some aspect of a technological development or use. Other stakeholders have a strong interest in the consequences of the technology for themselves; those consequences are often driven by economic interest, e.g., impacts on small businessmen; occupational consequences, and structural unemployment on workers; health and safety effects on the individual; concerns about consumer safety. Stakeholders are likely to seek to influence the design and operating characteristics of the technology, the structure of the market and of the industry, and the way in which the technology is priced, distributed, and regulated.

Almost always there are conflicts among the objectives and responsibilities of major stakeholders, and out of these conflicts are defined policy issues which must be resolved. It is rarely in the interest of any advocate stakeholder to identify and call attention to some possibly troublesome characteristic of the technology and thus to define it as an issue to be dealt with. Usually a problem is overlooked until the technology is widely utilized and the problem has become visible beyond doubt. Similarly, if it is not in the interest of any major stakeholder to identify and plan for beneficial applications of the technology, some of these may be overlooked. More often than not, the advocate stakeholder is interested in the relatively short-term effects of the technology on his market. He is interested in the short-term benefits. He is interested in creating or expanding into a market. The short-term considerations so characteristic of American business therefore are consistent deeply structural distractions away from longer term markets, longer term economic developments, and longer term societal concerns.

The theme of this chapter is that the interests of the dominant technological stakeholders will not draw attention to the potential environmental, health and safety implications of telematics technologies, either benefits or costs. The stakeholders are focused on the problems of coalescence and convergence of telecommunications, computers, and information technology. Their focus is on the question of moving into new markets. Those stakeholders who have traditionally been unregulated, such as computer manufacturers, are interested in moving into and integrating with those areas previously highly regulated, such as telephone, radio, and television. The technological stakeholders are to a large extent devoted to managing the questions raised by the regulatory apparatus that they are currently immersed in. Other technological advocates are concerned with the questions of intruding into those regulated technological areas with institutional, economic, organizational, and technological innovation. As will be seen in the discussion of affected parties, their concerns, as they now stand with regard to telematics, are relatively circumscribed, focusing on such questions as privacy, monopoly, constitutional guarantees, copyright, and equity of access.

The fact that not even the largest stakeholders in the telematics game have a plenary interest in its benefits and costs in no ways implies criticism of those stakeholders except insofar as the failure to attend to cost and benefits works to their own detriment. The technoeconomic system in the United States, with its strong economic incentives coupled to the institutionalization of technology promotes a tendency to limit rather than to broaden the scope and time horizon of each actor's concerns. The fact that the sum of individual self-interests does not fully map longer term consequences is again neither an explicit nor implied criticism of the dominant actors. It is just another aspect of our technoeconomic reality. These two situations, however, are no justification and ought not to preclude attention by government to a full range of potential benefits and possible social costs. Only when we understand the limitations on the likely range of actions of each of the dominant actors can government begin to frame the special, necessary, and complementary role for its own actions.

If EPA is to effectively introduce environmental considerations into discussions of national information/communication policy, it must take into account the advocate stakeholders' and interested parties' self-interest and related indifference to some matters.

WHY ANY EPA (OR GOVERNMENT) ROLE WITH REGARD TO TELEMATICS?

One widely accepted guiding principle for defining the appropriate role of government in regard to technology, is that government should intervene only to balance imperfections in the market. This phrase unfortunately is almost meaningless with regard to telematics. One branch of the technologies which are rapidly converging and integrating to make up telematics—telecommunications—has, as already noted, long been dominated by regulated monopolies which still enjoy and are constrained by some anomalies of that position. The other two streams from which telematics is developing—electronics/computers and information services—have throughout their development been heavily subsidized by military and civil sector agencies through research and development funding and procurement. In many forms of telematics, Federal agencies are major actors (for example, electronic funds transfer, in which the Federal Reserve System operates some of the critical systems and links); in many other forms, Federal agencies are critically dependent on the technologies (for example, military dependence on communication systems and satellites). Telematics provides the indispensable interface between our nation and other nations, and between the various parts of our nation and of our government, a fact which in most countries is recognized by government ownership of communication systems.

The electronics/computers and information services components of telematics have not been much regulated, and in fact—because they have developed rapidly and their capabilities are to a large extent historically unprecedented—older laws and legal conventions and precedents often do not "fit" them. There have been cases of courts ruling that computer theft of data could not be prosecuted because that which was allegedly stolen was not tangible. Another example is the confusion and controversy attending copyright law and telematics.

It therefore seems that the appropriate role for government with regard to telematics cannot, realistically, be no role at all. At the same time, in accord with prevailing political attitudes, it should be defined to be limited by some commonsense rules. This assessment, of course, was not aimed at formulating an appropriate role for the Federal government with regard to telematics, nor an appropriate role for EPA. But in offering guidance and advice with regard to research needs, as they relate to telematics, we have of necessity had to consider EPA's legislated mandate and authority in the context of future telematics development. The assumption which we have used, which should be stated explicitly here, is that:

- Within constitutional limits, resource constraints, and political realities, the Federal government should act where the potential public benefits of telematics would not be delivered without such actions, or where avoidable social costs would be imposed without such actions.
- With regard to environmental protections and public health, EPA should similarly act to achieve potential benefits of telematics which would not be provided by private sector actions, and to avoid or minimize potential costs which would otherwise be imposed on the public.

The next part of this section identifies major stakeholders and describes their stakes in the future of telematics, in order to see whether opportunities for beneficial environmental and health applications are likely to be quickly realized; and whether any possible environmental or health impacts of a detrimental nature are likely to be anticipated and controlled in a timely fashion. The following part considers the potentially affected parties, a broader group which includes not only stakeholders but all of those who may be indirectly impacted by telematics but are less able to influence its development.

Some of these potentially affected parties will find their well-being, opportunities, and choices increased and improved. Some will inadvertently be subjected to undesirable health, social, environmental, or other costs. In the case of telematics, it is likely that the potentially affected parties include nearly everyone in the society. Most are unlikely to have informed and explicit expectations about these effects. Unlike institutional stakeholders, ordinary citizens are likely to know little about telematics as it develops, and to make little effort to have an influence on its design or use. Of course, in the American political system, there is no voice for the generality. Organized power is the only power which affects public policy decision-making. Consequently, those concerned with the effects of telematics are likely to find their most effective voice when organized into groups capable of impacting on the legislature, the regulatory agencies, and other elements of government.

A fourth subsection looks more closely at economic and market issues since these will affect the timing and scale of utilization of telematics and thus the significance of possible environmental, health, and social impacts. The final subsection treats public policy issues in their relationship to environmental concerns.

MAJOR STAKEHOLDERS: OBJECTIVES AND ENVIRONMENTAL INTERESTS

Industry

Because telematics development is taking place largely within the private sector, the key stakeholders are corporate developers, suppliers, and promoters. The "telematics industry" is in actuality many industries, now converging, colliding, and coalescing. There are, first, the telecommunications companies—the common carriers and specialized carriers. They include the regulated monopolies which dominated the older telecommunications industries, and scores of more recent competitors ranging from very small specialized new companies to multinational corporations.

The telegraph, telephone, and submarine cables were quite different means of communications, and each tended to have the characteristics of a natural monopoly./1 They came to be regulated accordingly. Newer technologies have broken down the old categories to compete with existing systems and with each other. These conflicts between stakeholders have caused questions of market structure, entry barriers, pricing policy, and a range of services to be defined as dominant policy issues. We will come back to these in the fourth section below.

Secondly, there is the computer/business-machine/calculator industry--those who develop and those who manufacture the hardware, and those who develop and sell the software. This industry is itself very diverse. Some companies are integrated backward or forward—back to research and development, forward to information banks and consumer services.

Thirdly, there is the information industry—those who use telematics to collect, aggregate, analyze, manipulate, package, and sell or provide data of one form or another.

Even so broad a categorization, however, is misleading. One might, for example, speak of the electronic funds transfer industry as a subspecialty with telematics, and even this is a highly diverse set of actors including financial institutions of many kinds, communication links, government organizations, third party services, insurers, etc. There are numerous amalgamations of telematics with older, even competing, industries such as publishing.

With so diverse an industry there are obviously many differences in objectives, policies, stakes, and stances. But there are also stakes which are common to these private sector actors. First, they all want the telematics market as a whole to grow; they want the public to accept telematics, to expect and demand continual improvement and advancement, and to structure their work and leisure activities and institutions to be dependent on telematics. Secondly, they want freedom of competition preserved since in a very fluid situation each company sees opportunities to expand its market, diversify its products, and/or integrate its services so as to invade new areas of activity. At the same time, each wants competition limited so as to protect past investments and future expectations. Government support and protection is sought, especially vis-a-vis foreign competitors, but government regulation is generally viewed as an onerous and costly burden. No philosophical or political position is implied in this description; it is merely realistic to recognize that these major stakeholders want to maximize their opportunity for future profits, growth, and stability.

The older quasi-monopolies and the new competitors are scrambling to use the latest scientific and technical developments in telematics. It is not in the interests of these major stakeholders to identify or call attention to any environmental, health, and social problems associated with them, which they believe to be unimportant, not their responsibility, or effects which will take care of themselves with the passage of time. Such problems can for the moment be ignored, deferred for later, or treated as externalities until there is public pressure to recognize them.

It is in the interests of these stakeholders to develop new users and customers for telematics, including environmental and health applications, such as pollution monitoring devices. But since these are only two areas of need among many potential lucrative markets, it may require some initiative and encouragement by potential users to assure timely development.

Government

Because of events and decisions made early in the history of the American communications and information industries, the government role with regard to them is powerful but limited and reactive. In most other countries, telegraph and telephone systems are combined with the postal service and operated by the government. In the U.S., private sector investment and entrepreneurship built these systems with little or no government assistance /2, and reliance on the private sector has continued to be a fundamental tenet of government communications and information policies. When the government undertook to regulate these industries in 1934, it was in order to deal with economic and market issues and to regulate the spectrum as a scarce resource./3

The most important government sector with regard to telematics has been the Federal Communications Commission (FCC), a regulatory agency, although Federal R&D—especially military R&D—has contributed much to telematics development. Like most U.S. regulatory agencies, the FCC has a specific, limited legislative charter, and it has no special responsibilities for environmental and public health concerns related to telematics. It deals with market issues and to a lesser extent with programming content.

The consequences of historical development of control over the telecommunications industry in the United States and the division of responsibility within the industry differ from those in other advanced nations. One effect has been to blunt any integrated forward look by the telecommunications regulatory apparatus. The effect of that, one can see even in the most casual evidence. The Canadians, French, and British are all far ahead of the United States in developing modern telematics systems, information utilities, and broad-scale intervention experiments to test and evaluate the technologies. The major opportunities for long-term development are lost in our parochial squabbling. The lack of a national policy on telematics and telecommunications is leading to an inchoate system of development. Coping with that incoherence is a major activity of both the regulators and the regulated.

The National Telecommunications and Information Administration (NTIA), established by Executive Order 12046 in 1978 within the Department of Commerce, is the principal Federal agency for development and implementation of national policies on electronic communications. It inherited the functions of two older offices, the Office of Telecommunications Policy which had been within the Executive Office of the President, and the Office of Telecommunications in the Department of Commerce.

NTIA has five responsibilities:

- to advise the President on policy issues related to domestic and international communications and information;
- to present and advocate the Administration's policies to Congress, the public, the FCC, and other Federal, State, and local government agencies;
- to encourage the development of new technology and management techniques which will maintain the effective growth and application of telecommunications;
- to manage the Federal government's use of telecommunications and recommend procurement policies for all Federal agencies; and
- to coordinate Federal assistance to State and local governments in planning and use of telecommunications systems.

The thrust of NTIA's responsibilities are promotional and developmental. The agency, however, also concerns itself with problems and issues related to telecommunications. For example, at the initiative of the President's Office of Science and Technology Policy, in 1979, NTIA organized an inter-agency task force to prepare a detailed plan for a Federal program on understanding the biological effects of nonionizing radiation, and published a report in June 1980.* Other problems of concern to NTIA are questions of system security and privacy, issues of deregulation, management of the broadcast spectrum, extension of telecommunications services to remote and rural areas, and planning for expansion of electronic mail and electronic funds transfer.

The Senate Committee on Commerce, Science, and Transportation of the 97th Congress, 1st Session, favorably reported out a bill to establish a cabinet-level International Telecommunications and Information Task Force which would operate for three years to "develop consistent and comprehensive U.S. internation telecommunications and information policies." The bill (S.821) provided a clear justification for a government role in telematics development:

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* Nonionizing Electromagnetic Radiation Safety, A Program of Coordinated Federal Activities Related to Biological Effects of Nonionizing Electromagnetic Radiation (0-300GHz), NTIA-SP-80-7), June 1980.

"The Congress finds that -

(1) the United States telecommunications and industries make an important contribution to international commerce and are vital to the economy of the United States;

(2) although many governments of the world have recognized the strategic importance of their telecommunications industries and have developed policies to promote those industries, and the United States has no coordinated international telecommunications and information policies...."

(Sec. 301, to be cited as the "International Telecommunications and Information Coordination Act of 1981.")

A bill introduced in the House (H.R.3121) has essentially the same purposes.

The Department of Defense may in fact have a greater influence on telematics development than the FCC or NTIA. Communications and computers are of course critical to military security and for four decades the Department of Defense has funded basic and applied research in these areas. DOD has the largest private switched telephone network in the world—Autovon, built by the Bell System./4 It also has communications satellites, such as the Defense Satellite Communications System, but leases an equal satellite capacity from commercial vendors. The needs of the military forces are an important driver in design and development of telematics because DOD is one of the largest users. Its influence extends further. The U.S. Justice Department brought an antitrust suit against AT&T in 1949, aimed at forcing divestiture of Western Electric. In 1953, the Secretary of Defense advised the Attorney General that breaking up the integrated Bell System would pose a threat to military security./5 The suit ended with a consent decree in 1956 with no substantial breaking up or limiting of the Bell System. At present there is much concern in DOD about vulnerability of communications to electromagnetic pulse, as mentioned in the last section, and it is thought that this may eventually stimulate greater use of fibre optics, which are not susceptible./6

The early telecommunciations technologies—the telegraph (1840s), submarine cables (1860s), and telephones (1880s), had few detrimental environmental effects. Those effects were mostly associated with stringing transmission lines, which began at a time when environmental values were low. No public health problems were ever identified in connection with these technologies. On the contrary, there were obvious and substantial benefits in medical care delivery and in response to disaster. Neither the public nor the government therefore had any reason to associate communications technologies with environmental assault.

From the beginning, the telegraph system helped to open up and civilize the West. The telephone and radio later also improved the quality of life in rural and remote areas. Communications and postal systems along with the railroad and later the highways, played a major part in integrating the U.S. economy and policy across a huge land area with diverse topography, climate, resources, and population. Communications thus contributed to the spread of population and to present patterns of communities, population densities, lines of commerce, and industrial location. These technologies had, and telematics will have, great but indirect impacts on our environment.

These are indirect impacts because in affecting regional population patterns and industry location, telematics is largely a facilitator rather than a prime mover. The appeal of the Sun Belt may be enhanced by ready telecommunications and data access, but climate nevertheless is the primary factor. The desire to abandon aging center cities, populated with a questionable work force is a primary corporate driver to suburbia. The fact that a telecommunications line may provide central control to distributed work centers is a facilitator. Moreover, the U.S. does not have and has never had a national population distribution policy, or a national land use policy.

There is, therefore, no Federal agency with a primary mandate to define land use issues or investigate environmental impacts with regard to telematics. The exceptions to this are OSHA and EPA's Radiation Health Program which are clearly the agencies responsible for health and safety of microwave radiations. Division of governmental labor means division of governmental responsibility, which means fractionated, limited approaches to complex problems.

Telematics can be contrasted with some emerging technologies for which the Federal government has taken at least partial responsibility in development stages, for example, aviation, oil shale, solar energy, hydropower, and public transportation. When a government agency such as the Department of Energy or the Department of Transportation is given developmental responsibility it is also mandated by law (NEPA, and others) to give thorough attention to environmental concerns. It comes under immediate and intense scrutiny by public interest groups who watchdog government agencies.

In the case of telematics, however, the Federal government by and large is not a developer for civil sector use. Even though Federal R&D influences development and the government has a strong influence as a major potential user, its involvement does not have the direct and driving implications and effects that it has had with regard to public transportation, hydropower, and aviation. Thus, only such general environmental and health agencies as EPA and OSHA have a responsibility, and that implicit rather than explicit, to raise questions about environmental and health aspects of telematics. But even the structure of EPA and OSHA and the realities of bureaucratic life are likely to act as strong deterrents to either of those agencies undertaking a synoptic examination of the future impacts of telematics. This reluctance is in part accidental to the structure of American government and not intrinsic to the structure of government. A recent volume by Nora and Minc, The Computerization of Society: A Report to the President of France, does attempt a synoptic view of telematics and does attempt to deal with the issues which in the American system are perceived as interstitial and hence lost in the cracks.

Users of Telematics

Individual and institutional users and potential users of telematics are also stakeholders. They actively seek appropriate applications of telematics in the belief that these technologies will increase the effectiveness, productivity, and efficiency of current activities or allow them to develop rewarding new activities. Potential commercial users are likely to seek further information about the technologies and to try to influence their development and design. To the extent that potential users include environmental managers and health care practitioners, this self-interest will fit in with supplier motivations to speed up new and putatively beneficial applications. Exhibit 6-1 lists some present and potential users of telematics.

Users, however, are not equally able to anticipate—or equally motivated to anticipate—possible benefits or detrimental outcomes. Such foresight often requires scientific and technical information which is proprietary, or otherwise not available to potential users. Also, environmental and public health effects are likely to be subtle, diffuse, and broadly distributed, as well as only peripheral to the specific concerns of any one corporation, institution, or household. Finally, in spite of the environmental legislation of recent decades, most environmental impacts can be and are still treated as externalities to be ignored or passed on.

Workers

A fourth major category of stakeholders is labor. This includes workers who manufacture telematics devices; workers who provide telematics services and otherwise work with and on telematics devices; and workers who may be replaced by telematics. This last group is discussed in a later section.

Workers employed in production of telematics generally fit into established labor categories such as assembly line worker or operator, and have in general concerned themselves with the same kinds of issues as other production workers, namely wages, benefits, hours, promotions, and security, rather than focusing on the technology itself. However, workers often raise questions of occupational health and safety before they are recognized by either medical practitioners or industry. It sometimes takes a long time for their complaints to be recognized and officially investigated and acted upon.

Those who work with telematics devices have tended to identify themselves as professionals (e.g., computer programmers) and managers whenever possible, and otherwise as white-collar workers. Such workers generally tend not to be organized, and tend to identify themselves with the interests of the employer. Their telematics machines, moreover, often become a badge of status and a symbol of expertise. In spite of these inhibitors, however, it is from these groups that there have been recent allegations of health problems associated with telematics.

Exhibit 6-2 lists a number of labor unions with direct interest in telematics. They are concerned with the installation and maintenance of telematics equipment or represent workers employing telematics in their jobs. With the exception of the acute attention that the Communication Workers of America (CWA) has given to telematics and its future because of its direct occupational connection with it, we find that most of organized American labor, and presumably, therefore, an even greater percentage of nonunionized American labor, is unaware of and effectively unconcerned about the long-term

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EXHIBIT 6-1: STAKEHOLDERS AND POTENTIALLY AFFECTED PARTIES

Stakeholders and Potentially Affected Parties	Major Concerns, Interests, and Objectives	Environmental and Health Concerns
I. Stakeholders		
. Developers/Promoters		
Equipment developers and Manufacturers	Market shares, growth, profits, patents, big systems and big volume products.	Positive: markets/clients for environmental monitoring and control devices. Negative: environmental/health regulations would constrain options and add to costs.
Software Developers	Same as above.	Positive: markets/clients for environmental/health related programs.
Information Providers	Maintaining position	None specific.
Providers of Communication Services		
Communications common car. Domestic:		
· Established systems: AT&T, Western Union	Position as protected/regulated monopolies; market shares for competitive private line services; profits, growth, patents; protecting sunk investments.	Negative: confirmation of hazards from microwave, nonionizing radiation, etc., would threaten or constrain new options and opportunities.
Competitors: many new and potential private line and microwave services.	Competitive position; profits, market share, growth; all dependent on deregulatory and other decisions by Congress and FCC.	Same as above.
International: Established: 6 IRCs,* AT&T, Comsat	Same as domestic established systems.	Same as above.
Western Union	Recision of Sec.222; agreements with PTTs; new clients.	Same as above.
AT&T	Same as above.	Same as above.
Many potential new competitors.	Full recision of FCC barriers to competition; agreement with PTTs; new clients.	Same as above.
Federal Government		
NTIA	Mission to encourage telematics development, orchestrate Federal role; reflect Administration policies.	No primary concern; when critical concerns & issues arise, will be responsible for advising President and developing policy.
FCC	Implementation/enforcement of regulatory legislation dealing with economic and market issues and spectrum use.	No specific responsibility.
U.S.Postal Service	Competition of electronic mail services with USPS constitutional monopoly, especially erosion of revenue producing categories of mail service entry into electronic mail.	None
Other Federal civil agencies	Procurement of appropriate telematics devices, services, and systems for carrying out mission, within Federal guidelines.	No environmental/health guidelines yet developed. Some potential interest in health and environmental agencies.

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* International Record Communications Companies.

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EXHIBIT 6-1: STAKEHOLDERS AND POTENTIALLY AFFECTED PARTIES (cont'd)

EPA	No specific mission with regard to telematics.	Radiation safety implementation of national environmental policies and laws; environmental monitoring, standards-seting, etc. (Early warning + a nascent role).
OSHA	No specific mission with regard to telematics.	Radiation safety implementation of occupational safety and health legislation and policies; rule making.
Congress	General: legislation for national security, general welfare, etc. Constitutional commerce clause, Bill of Rights, etc.	General: policy formulation and legislation where needed.
Courts	Interpetation/application of legislation, protection of rights and liberties, settlement of disputes, equity.	Same, applied to environmental and safety and health legislation.
State and local government.	Use of telematics for productivity and efficiency in carrying out all governance functions not delegated to Federal Govt. Special interest in use of telematics for community infrastructure management	General intrastate responsibilities for environmental/safety/health; especially concerned with solid waste, water, etc. Site-specific impacts of telematics. Local and urban environmental and resource management.
. Users and customers: . existing and potential, corporate, institutional, household, individual, public and private sector.	Increased efficiency and productivity in existing activities and with regard to existing technologies; substitution for older technologies and practices; development of new activities; also comfort, convenience, amenities, etc.	(1) for some users: appropriate applications for use in environmental, health, and safety activities. (2) avoidance of direct detrimental impacts on individual or institution. (3) externalization, avoidance, reduction of detrimental impacts from own use of telematics, at lowest cost. (4) low level motivation to avoid general (public) health and environmental problems.
. Labor:		
1. in telematics production.	Employment, security, wages, benefits, hours, etc.	Avoidance of detrimental effects on occupational safety and health, if such are identified.
2. in other industries but using telematics devices.	Same as above, plus status and benefits from telematics (i.e., white collar status)	Same as above.
3. potentially displaced by telematics	Job replacement or security, job upgrading.	Same as above.
4. future generations	Availability of entry level jobs.	

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EXHIBIT 6-1: STAKEHOLDERS AND POTENTIALLY AFFECTED PARTIES (cont'd)

2. The Potentially Affected Parties

A. General

Telecommunications-focused Public Interest Groups	Free speech, civil liberties, freedom of (govt.) information; privacy; content: libel, false advertising, pornography, TV violence, etc.; equity of access	No special interest or concern.
Environmental Interest Groups		Generally focused on pollution and hazards related to resource development, fossil fuels, facilities construction, transportation, industrial byproducts, power generation, etc. Little attention to effects of decentralization or other long term structural questions. Spotty interest in use of telematics, such as remote sensing, etc.
Labor (general)	Employment, security, wages, benefits, hours, working conditions, etc.	Occupational safety and health.
Individuals,households.	Diverse: economic and social wellbeing in high priority.	General concern for environment thought to be stable and relatively strong, but focuses on high visibility issues. Growing concern for internal environment. Environmental threats to health.

B. Special interests

Elderly	Maintenance of accustomed quality of life, generally under conditions of reduced or restricted income, health, mobility, and social relations.	Availability and quality of health care and emergency services.
Disabled/handicapped	Overcoming constraints on normal functioning and mobility, compensatory support systems.	Same as above, plus prostheses.
Health care professionals	Prevention, diagnosis, and treatment tools and techniques; cost containment; status and income.	Scientific knowledge and data about environment-related disease.
Architects, engineers, builders, building managers.	Meeting changing client needs, building new capabilities, etc.	Interior environment, related health and safety concerns.
Farmers, agribusiness	Productivity and efficiency of food production and distribution systems, commodity pricing; small farmers especially concerned with maintaining economic viability of family farms.	Short and long-term quality and productivity of soil, availability of water, pest control, weather prediction and control, flood control, optimizing agricultural practices.
Wood products industry and forest managers	Long term markets, productivity, efficiency	Pest and disease control in forests, fire control, competitive demands for and on land.
Fishing industry	Maintaining and increasing yield. International relations.	Quality of ocean environment, incompatible uses of oceans.
Minerals industry	Opening up public lands, market supply and demand, public policy	Generally view environmental regulations as restrictive and costly.
Public lands managers	Multiple use development; accomodating conflicting demands and policies	Environmental protection on public land under increased development and use
Disaster response	Coping with disasters, advance planning, prevention	Monitoring/warning systems for both acute and slow-building or cumulative disasters (e.g., drought)

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EXHIBIT 6-2: LABOR UNIONS WITH AN INTEREST IN TELEMATICS

- Communications Workers of America
- American Postal Workers Union
- Associated Actors and Artists of America
    - Actors Equity
    - AFTRA
    - Screen Actors Guild
- National Association of Broadcast Employees and Technicians
- International Brotherhood of Electrical Workers
- American Federation of Government Employees
- American Federation of State, County, and Municipal Employees
- National Association of Letter Carriers
- Laborers International Union of North America - Mail Handlers
- International Association of Machinists
- American Federation of Musicians
- Newspaper Guild
- International Print and Graphic Communication Union
- American Radio Association
- International Alliance of Theatrical State Employees and Moving Picture Operators of the United States and Canada
- American Federation of Teachers
- United Telegraph Workers
- International Typographical Union
- International Labor Press Association

All of these unions come under the AFL-CIO's Department of Professional Employees.

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role of telematics in American society. Organized labor is the sleeping giant among stakeholders in telematics, considering its enormous potential for framing positive alternative futures for American work life, American home life, and American society in a highly telemated world.

Exhibit 6-3 is a vignette of one stress and health hazard problem of workers in the office of the future.

In summary, the key stakeholders—those who could most easily raise to public attention some public policy issues which should be addressed with regard to telematics—are:

EXHIBIT 6-3: TELEMATICS HEALTH HAZARDS—A VIGNETTE

In San Francisco this winter 1100 members of the Office and Professional Employees Union No. 3 began picketing the offices of Blue Shield of California in a contract dispute involving wages and the working conditions of half its membership, video display terminal (VDT) operators. Demanding improvements such as hourly breaks for the operators and renegotiation of data entry production standards, the union has had minimal success in affecting a dialogue with Blue Shield. The company has stated that improvements have already been made (window curtains to reduce glare, dimmer switches for overhead lights, and keyboard changes), and that rest breaks are not negotiable since "employees should be on the job to work and if they don't want to, they shouldn't be here" (John Rogers, management spokesman, quoted in Computerworld, 2/16/81)

Although both sides have stated that it will not affect negotiations, Blue Shield was one of five Bay area sites studied by the National Institute for Occupational Safety and Health(NIOSH) last year at the request of a coalition of area unions. The other four sites for this investigation into employee health and VDT use were "newspapers or related operations". The results, while not blaming VDT's for all increases in job-related stress and physical health problems, did point to specific detrimental impacts among certain groups of workers. (Select Research Reports on Health Issues in Video Display Terminal Operators;NIOSH, Div. of Biomedical and Behavioral Science, April, 1981)

NIOSH included in its study 254 VDT operators, clerical and professional, and 157 clerical control subjects. Of the professionals, none worked for Blue Shield, and all of the participants were volunteers. The study found that professionals using VDT's experienced less stress and physical complaints than clerical operators or members of the control group; apparently because they exercised more self-control over jobs having greater variety. The clerical workers using VDT's experienced the highest levels of stress and discomfort, and throughout the study proved to be the most affected of the three groups. They reported heavier workloads, more boredom and fatigue, and more anxiety over job futures. Paradoxically, they also appeared to have higher self-esteem than the other groups. According to NIOSH this means that VDT's may increase stress where it already exists, but are only a component of the overall problem.

For physical problems, the effects of VDT's are clearer. Visual complaints related to image resolution, lighting problems, and viewing distance are perhaps as much related to design of the workplace as to the terminal itself. Musculoskeletal complaints resulting from the posture necessary for viewing and keying are also tied to both machine and environment.

For the strikers in San Francisco these results have interesting implications. It has been shown that their complaints are real ones and largely a result of the design of the workplace. There was no strong correlation found between time spent at the terminal and health complaints, a point in the company's favor. Since clerical VDT operators apparently achieve high self-esteem despite health complaints, it may not be difficult for Blue Shield, or any other company, to replace the striking workers, and it may be to the company's advantage to go this non-union route. It is clear that employers contemplating the use, or increased use of VDT's should design new facilities, or redesign existing ones to conform with the physical needs of the operators. It is not enough to simply place terminals in a room and commence operations now that appropriate design techniques have been established.

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*Source: NIOSH, Select Research Reports, April, 1981

EXHIBIT 6-3: TELEMATICS HEALTH HAZARDS—A VIGNETTE (cont'd)

Percentage of VDT Operators and Controls Reporting Frequent Levels of Particular Stressors Showing Significant Differences[1]

Stressors	Clerical VDT	Professional VDT	Control
Interesting work	24	76	53
Bored with work	48	15	23
Work is dull	42	13	27
Increased concentration required	45	26	34
Able to choose own work	4	28	18
Dislike workload	45	15	21
Unhappy with workload	36	17	21
Have to work too hard	76	53	61
Behind in work by at least one week	27	10	8
Heavy workload	82	70	73
Dissatisfied with workpace	41	17	18
Have to work too fast	82	65	65
Can set own workpace	41	61	73
Certain in career future	14	37	44
Promotion opportunities	13	37	31
Worry about reprimands	24	3	8

[1] Significant at the 95 percent confidence level or greater using a Chi Square test for homogeneity.

- corporate investors, developers, manufacturers, suppliers, and promoters,
- users and potential users, spread widely through both public and private sectors,
- the labor force associated both with telematics developers and telematics users, and
- two Federal agencies, the FCC and NTIA.

Some members, at least in the first three groups, have a stake in realizing the potential environmental and health benefits from telematics by encouraging further applications for environmental monitoring, pollution control, and similar uses. None of the four major groups appears to have a strong stake in investigating, anticipating, assessing, or revealing any undesirable environmental and health characteristics of telematics. Certainly none has specific responsibility for considering or acting in respect to indirect effects such as decentralization, or changing population and land use patterns.

The attention of some of these stakeholders has been drawn to some aspects of telematics by quite conventional mechanisms; acute episodes of health effects, such as the exposure of soldiers to radar; inexplicable actions of foreign powers, such as the bombarding of the American Embassy in Moscow with microwaves; sharply localized concerns about military sites such as Project Sanguine, the attempts to use the courts to provide relief from real or alleged technological injury; a widespread institutionalized suspicion of new articles in commerce, as reflected in consumer product safety concerns; and finally, interest in a major new macro engineering project, the solar power satellite. Each of these illustrations has heightened interest in the human and environmental consequences of microwave radiation. Few telematic techniques have such continuing, diverse, and convergent attentive publics.

Other major government stakeholders as suggested in Exhibit 6-1, such as the Department of Housing and Urban Development, the Department of Transportation, the Department of Energy, and the Department of Commerce, are effectively indifferent to the potential primary impact of telematics technology on their areas of concern. Even more remote in awareness and concern are the financial institutions of government which have tremendous power to influence the outcomes in the employment of new technologies. The Federal Home Loan Bank Board, and institutions concerned with monetary and fiscal policy such as the Treasury Department and the Internal Revenue Service, have chosen to put themselves completely out of it.

Government as stakeholder also includes the Congressional committees (Exhibit 6-4). They have so far been slow to demonstrate real interest and concern over telematics, awareness of the potential for the future, or willingness to act in an integrated and coherent way.

POTENTIALLY AFFECTED PARTIES

Should telematics become as extremely pervasive as many thinkers believe, nearly everyone will be affected. Some institutions and some groups will enjoy especially large benefits and some will be subjected to unusally large penalties or social costs. Such groups are in fact stakeholders in the future of telematics, but because they are outside the primary decision-making process (in this case, the market or buyer-seller-regulator relationships) they have little direct leverage for influencing the technologies' development. In many cases, of course, potentially affected parties have little or no prior realization that they will be affected by the technology.

When such latent interest groups do realize that they will be affected, they often attempt to find some leverage by creating or joining a public interest group.

In the past, most of the social and political controversies which have arisen around communication and information technologies (in addition to the economic issues defined by the major stakeholders) have dealt with:

- constitutional guarantees of freedom of speech and associated civil liberties,
- citizens' demand for information about government actions and decisions,

EXHIBIT 6-4: CONGRESSIONAL COMMITTTEES WITH INTERESTS IN TELEMATICS

U.S. Senate

- Committee on Commerce, Science, and Transportation
  - Subcommittee on Communications

- Committee on Banking, Housing, and Urban Affairs
  - Subcommittee on Health and Scientific Affairs
  - Subcommittee on Financial Institutions

House of Representatives

- Committee on Interstate and Foreign Commerce
  - Subcommittee on Communications

- Committee on Science and Technology
  - Subcommittee on Transportation, Aviation, and Communications
  - Subcommittee on Space Science and Applications
  - Subcommittee on Investigation and Oversight

- Committee on Banking, Finance, and Urban Affairs
  - Subcommittee on Financial Institutions Supervision, Regulation, and Insurance

- Committee on Government Operations
  - Subcommittee on Government Information and Individual Rights

- Committee on House Administration
  - Subcommittee on Libraries and Memorials
  - Subcommittee on Printing
  - Policy Group on Information and Computers

- Committee on the Judiciary
  - Subcommittee on Civil and Constitutional Rights

- Committee on Post Office and Civil Service
  - Subcommittee on Postal Operations and Services
  - Subcommittee on Postal Personnel and Modernization

Joint Committees, Boards, Etc.

- Joint Committee on Libraries

- Joint Committee on Printing

- Joint Economic Committee

- Board for International Broadcasting

- threats to the privacy of individuals,
- the content of programming and messages: libel and slander, advertising, pornography, violence on television, etc.,
- copyright and patent law, and other questions of protection for ownership of information and ideas, and
- equity in access to systems, information, and services, and consumer prices.

Public interest groups which direct their attention to FCC actions and to the communication and information industries have generally formed themselves around one or more of these issues./5 They are not oriented toward environmental and health concerns and have little interest or information on them. On the other hand, the broader public interest groups direct their limited technologies on technologies such as resource extraction, power generation, and transportation which have had severe, localized, and highly visible unequivocal effects on the environment or demonstrably detrimental implications for public health. Because of the competition for their attention and resources, established interest groups are unlikely to give much attention to telematics unless new environmental and health problems are clearly demonstrated.

Labor in general has not so far defined itself as a major stakeholder with regard to telematics. Both the older industries such as telegraph and telephone systems, and later computers, microprocessors, and other telematic applications have created thousands of new jobs. Automation in the office and the factory has undoubtedly also destroyed many jobs, but while the economy was expanding this did not become a divisive issue./6 There have, however, been significant exceptions to this; for example, labor conflicts and strikes associated with the introduction of telematics into newspaper publishing. There are likely to be more such cases as telematics comes into craft occupations such as printing and highly unionized production jobs.

A special case is the production workers—assemblers, operators, and other manufacturing employees—whose jobs may be taken by robots. Until recently, the relatively small number of industrial robots were dedicated to work which is hazardous, conducted in toxic environments, or numbingly monotonous. In most cases robots were, and were perceived by the workers to be, generally beneficial in terms of occupational safety and health./7 As telematics makes stronger incursions into factories, the number of jobs in some categories, especially those requiring minimum education or training, will be reduced, and there may be growing antagonism and resistance to the new devices on the part of labor. If so, this would dispose workers and their organizations to look more critically at all characteristics of telematics, including their occupational health and safety characteristics, and may also lead to an extension of the concept of health and safety to include mental health.

Having looked at two broad categories of affected parties—the general public, represented by public interest groups, and the labor force—we can summarize more specific categories of people and institutions who will be affected, especially with regard to health, safety, and environmental quality, from the previous discussion of potential impacts (Exhibit 6-5).

It is unusually difficult to talk about alternatives to telematics, and thus one category of possible stakeholders is hardly mentioned in this analysis. Telematics has the special characteristic of either creating entirely new capabilities or transforming the ways in which things have traditionally been done rather than merely providing a marginal, incremental improvement in efficiency over older technologies. And yet it has repeatedly eliminated whole categories of crafts and employment classifications or changed their work beyond recognition. We need offer only one example here. Computer assisted makeup and imaging systems (CAMIS) is the combination of electronic page makeup or formatting with automatic printing on demand through computer driven imaging systems. Introduced into the printing and publishing industry—which thereupon becomes not a competitor but a user, and thus a positive rather than a negative stakeholder in telematics development—CAMIS eliminates a number of pre-press and press-run operations which have been regarded as a skilled craft, and thus eliminates not only discrete jobs but the basis of a lifetime identification of men with a kind of work in which they took great pride./8

Telematics has also affected the relationship between the news gatherers and editors. The ability in principle to go directly from typewriter to press drastically modifies the cycle of review and editing within the newspaper. As has already happened in more than one newspaper office, the prankster can introduce fake news, to hassle the editor. Presumably what one can do for amusement, one can do for gain or for spite. The question of vulnerabilities of the newsroom to these interventions is a matter that the press has so far chosen to ignore. It does illustrate the interesting matter of shifting vulnerabilities against a framework of static belief.

The magnitude of potential social impacts such as this, and the number of people and institutions which may eventually be impacted, explains why many people expect that telematics will be the basis for a social revolution or a new kind of society. Thus ubiquity of factors mocks any effort to specify potential stakeholders except in general categories.

FACTORS INFLUENCING THE DISSEMINATION AND USE OF TELEMATICS

As described earlier, the key stakeholders—chiefly corporate developers and users—have historically defined economic, especially market, questions as the dominant public policy issues related to telematics. Concerned publics have most often raised constitutional and libertarian issues. This section offers a brief look at the kinds of economic market issues which have affected telematics in the past. These may also affect the rate of adoption in the near future.

Issues related to market structure, competitiveness, fair practice, and pricing systems are complex because of the characteristics of information when considered as a market commodity./9 Some of these characteristics are:

EXHIBIT 6-5: LATENT INTERESTS OF AFFECTED PARTIES

Potentially Affected Parties	And Their Latent Interests
• Individuals and households	• Improved interior environments (indoor monitoring, alarm systems) Improved emergency and health care systems Improved prosthesis for the handicapped Improved communication, comfort, convenience, entertainment, etc. Possible impacts on medical care and housing costs Possible impacts of microwave radiation
• Medical and emergency delivery institutions and specialists	• More effective and efficient technology Possibly higher costs Possible reduction in professional independence Increased disparity between large and small institutions
• Local governments	• Improved tools for coordination and control of a variety of public services such as traffic control, disaster response, water and sewer treatment, air quality, crime prevention Possible problems with telematics device disposal (toxic substances) in the future Risk to firefighters from toxic fumes Effects of decentralization of population, industry, and work centers (Facilitated by telematics)
• Designers, builders, building managers	• Degradation of indoor environment; ozone emissions Monitoring of indoor environment Changes in work flow and indoor traffic flow
• Industry: owners, managers	• Improved productivity and efficiency Enlarged market opportunities Labor/automation trade-offs, labor relations Redesign of the work place - transformation of the factory Diverse effects on regulatory costs (OSHA)
• Labor	• Employment levels Skill requirements Occupational safety and health
• Farm owners, farm workers	• Increased productivity and efficiency Advanced market information Increased capital costs; disparities between large and small farms
• Resource development managers • Environmental managers • Disaster response managers	• Applications for monitoring, advance warning, pollution detection, etc.

- The same bit of information can be possessed and used by many people at the same time, unlike a gallon of gasoline, a diamond, or a loaf of bread;

- Information may become obsolete but it is not used up or depleted, and it is difficult to destroy;

- The same information can be generated by many people, from different sources, at the same or different times. Consequently, it is usually difficult to identify or prove the source of information;

- It is often difficult to display the value of information, without revealing the information itself;

- It is difficult to limit access to information; even those who have been induced to purchase it will often freely give it to others;

- The value of information often depends on its context or on its timeliness, like the results of this afternoon's horse race.

As noted in the case of electronic communications, market structure and regulation are complicated by other factors. The communications industry tended, so long as there were relatively few and discrete modes of electric communication, toward natural monopoly since the efficiency and effectiveness of the system increases geometrically with the number of individual connections. The high costs of equipment and government regulation also have tended to raise high entry barriers in this area. Universality of access, which has been an important but implicit objective of national policy (e.g., rural telephone lines, low postal rates for printed material) has led to interdependent pricing and cross subsidies./10 On the other hand, other parts of telematics, especially computer services and software production, has spawned hundreds of new companies and intense competition, with competitors ranging from multinational corporations to small businesses. The structure of the industry is highly fluid, with many kinds of horizontal and vertical integration being tried.

Competition is particularly acute in the information services segment of the industry. Computerized information services have proliferated; their data bases cover subjects and specialties ranging from the extremely broad to the highly specific and include proprietary and open information. A particular issue, i.e., conflict, which arises here is the relationship between government services and private sector services. For example, the National Library of Medicine has an information system called MEDLARS which encompasses 20 data bases, of which the largest is MEDLINE, containing indexes to 600,000 pieces of biomedical research literature. NML makes this information available at $15 per computer hour. This is less than a quarter of the cost of similar services offered by private companies, which are lobbying for legislation which would force the library, and presumably other government libraries and information services, to refuse the service to commercial users or to charge competitive rates. Libraries, however, insist that these services are merely logical extensions of their traditional activities and services.

Similarly to those who would skim the cream off the market created by AT&T, the private information services now wish to skim the cream off a system institutionally and technically created by the National Library of Medicine.

These kinds of conflicts can be expected to proliferate simply because the area of telematics is in more vigorous ferment than ever before. The collision, coalescence, and competition among the numerous technologies (see Section 2) for communication, computation, and information handling is more complex, profitable, and fluid than ever before.

Economic Issues. In order to specify the issues which have driven or directed the development of the existing telematics industry and the stakes which the various actors seek to protect, and the issues which, as a result, do and do not emerge into the public forum, it is necessary to look briefly at the history of communications.

The telegraph was the first major communication mode to transmit messages faster than humans could carry them by voice or in writing. (There were exceptions, such as smoke and drum signals, or semaphores. But they were very limited as to distance, content, speed, and accuracy.) The first landline telegraph in the U.S. was constructed in the 1840s. Transoceanic telegraph cables began with the transatlantic cable in 1866, and domestic telephones in the 1880s. The direct environmental impacts of these technologies were minor and, by and large, ephemeral. There were few or no health effects (other than making health care somewhat more accessible). They were hailed as great triumphs of human ingenuity. Public and governmental concerns focused only on access to the systems and economic impacts; ownership; and to some extent, privacy and censorship.

In most countries except the United States, domestic telegraphs and telephones were combined with the postal service and operated by the government. These postal, telegraph, and telephone administrations are now generally called PTTs. In the United States, private sector investment and entrepreneurship built these systems with little or no government assistance, and they began and remained under corporate ownership. A series of takeovers and mergers began almost as soon as the telegraph wires were strung. When the overseas cables were laid, interconnection with them increased the natural tendency toward monopoly. By the 1930s, AT&T and Western Union Telegraph dominated the telephone and telegraph systems, respectively./11

The progress of consolidation into monopolistic clusters is definitively illustrated with the historical example of telegraphy from 1850 to 1870 (Exhibit 6-6).

These systems, along with the railroad and highways, played a major role in integrating the U.S. economy and political system. Rural electrification in the 1930s and '40s, together with radio and universal postal service, went a long way toward reducing urban/rural disparities in culture, lifestyles, and values. At a later stage, radio and television may have helped to lure young people to the more glamorous life of large cities.

The policy issues which did become a big concern were the tendency of communications systems toward monopoly. In 1934, to have monopolies such as

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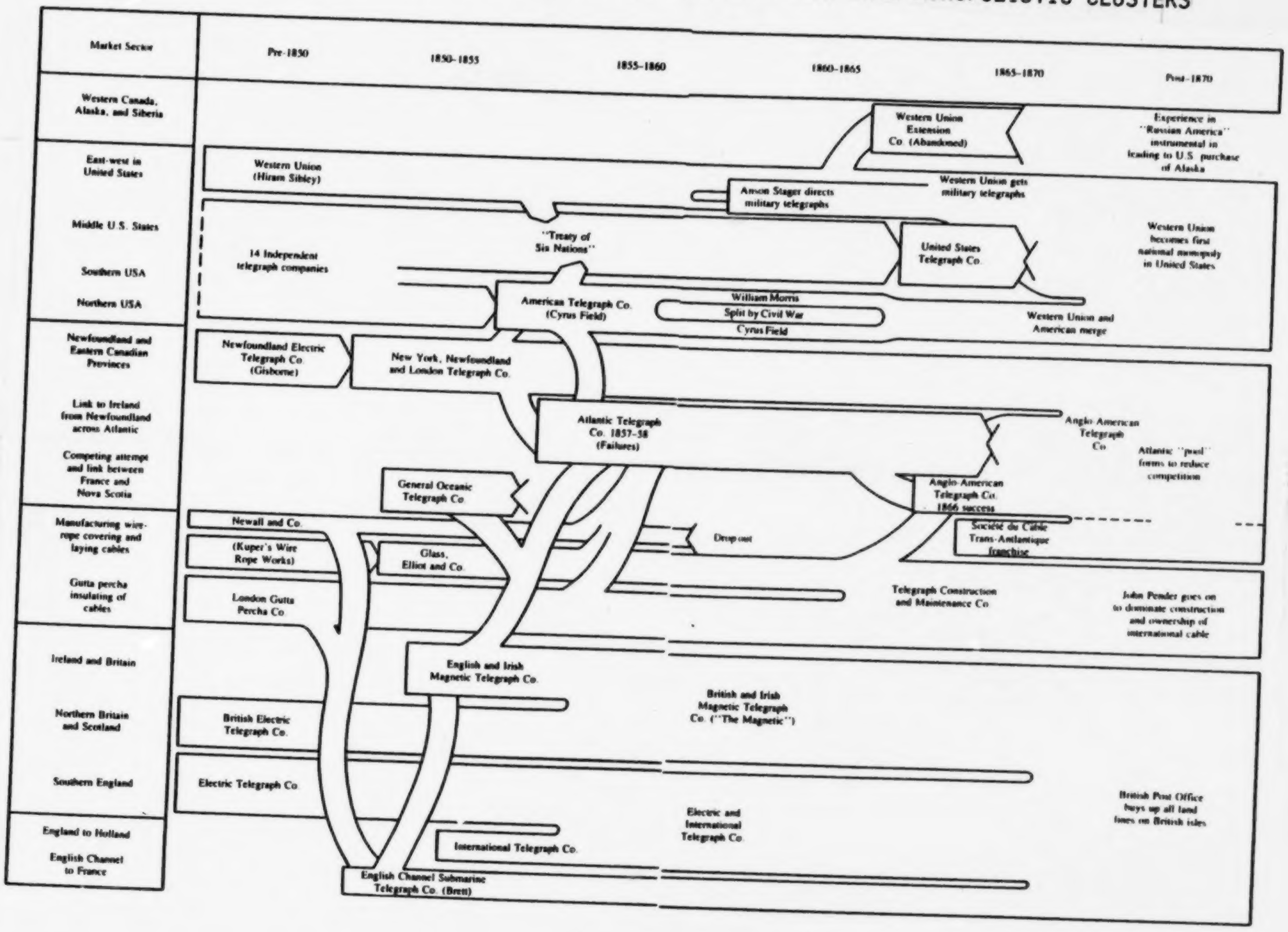
EXHIBIT 6-6: TELEGRAPHY'S PROGRESSIVE CONSOLIDATION INTO MONOPOLISTIC CLUSTERS


Market Sector
Pre-1850
1850-1855
1855-1860
1860-1865
1865-1870
Post-1870
Western Canada, Alaska, and Siberia
East-west in United States
Middle U.S. States
Southern USA
Northern USA
Newfoundland and Eastern Canadian Provinces
Link to Ireland from Newfoundland across Atlantic
Competing attempt and link between France and Nova Scotia
Manufacturing wire-rope covering and laying cables
Gutta percha insulating of cables
Ireland and Britain
Northern Britain and Scotland
Southern England
England to Holland
English Channel to France
Western Union Extension Co. (Abandoned)
Experience in "Russian America" instrumental in leading to U.S. purchase of Alaska
Western Union (Hiram Sibley)
Anson Stager directs military telegraphs
Western Union gets military telegraphs
14 Independent telegraph companies
"Treaty of Six Nations"
United States Telegraph Co.
Western Union becomes first national monopoly in United States
American Telegraph Co. (Cyrus Field)
William Morris
Split by Civil War
Cyrus Field
Western Union and American merge
Newfoundland Electric Telegraph Co. (Gisborne)
New York, Newfoundland and London Telegraph Co.
Atlantic Telegraph Co. 1857-58 (Failures)
Anglo American Telegraph Co
Atlantic "pool" forms to reduce competition
General Oceanic Telegraph Co.
Anglo American Telegraph Co. 1866 success
Newall and Co.
Drop out
Société du Cable Trans-Atlantique franchise
(Kuper's Wire Rope Works)
Glass, Elliot and Co.
London Gutta Percha Co.
Telegraph Construction and Maintenance Co.
John Pender goes on to dominate construction and ownership of international cable
English and Irish Magnetic Telegraph Co.
British and Irish Magnetic Telegraph Co. ("The Magnetic")
British Electric Telegraph Co.
Electric Telegraph Co.
British Post Office buys up all land lines on British isles
Electric and International Telegraph Co.
International Telegraph Co.
English Channel Submarine Telegraph Co. (Brett)

AT&T and Western Union operate in the public interest and offer reasonable rates, Congress passed the Communications Act. It established the FCC and was the first regulation of electric communications in this country. The legislation was modeled on railroad legislation; it was based on the assumption that competition would lead to wasteful duplication of capital facilities and services./12

The parallel to the legislative model for the FCC is the technical focus on AM radio broadcasts. Over the years each new innovation, from the FM radio to television to CB and cable, has been treated as variations on this one technology. The result is that early decisions become embellished and encrusted with incremental change directed at saving initial preconceptions.

The FCC, an independent commission, was to regulate both interstate and foreign communications by licensing and regulating common carriers. Common carriers were companies providing communication services for hire to the public and government by radio, telegraph, telephone, and later satellites. There are now about 1,000 common carriers, but this includes about 785 land mobile radio carriers and about 69 microwave radio carriers./13 Western Union Telegraph dominates the telegraph field, and AT&T, the telephone system. AT&T and its integrated Bell System now includes 23 independent local operating companies and a Long Lines Division, and Bell Laboratories and Western Electric, a manufacturing subsidiary./14 After the completion of this report, the Justice Department settled its seven-year long suit against AT&T which will lead to massive divestiture.

AT&T offers two kinds of services. The first is the well-known message toll service, and the closely related Wide Area Telephone Service (WATS) which provides leased lines under a monthly rate. The second type of service is a private line service which can transmit messages by voice, signal, television, or data transmission directly to a client's location./15

The evidence is that the message toll service must be technologically integrated, as it in fact is, nationally and internationally. That technological integration argues strongly for economic and management integration. The arguments are less clear with regard to the second class of service, since many kinds of institutions and many kinds of technological alternatives are able to supply private lines or dedicated facilities. Of course, the fact that there is a situation which will draw new big investors into telematics to compete with the established markets of the AT&T system is derivative of AT&T's success in establishing a mass market for its services. The newcomers are therefore in some sense competing for the market created by the telephone system. But this is in no way new to the American economy or the American political community. A crucial question which legislators and regulators have such great difficulty in addressing with regard to these questions is what is in the long-term public interest.

The old categories around which regulations were framed are rapidly being broken down by new technologies which do not fit distinctions between print and electronic, wire and broadcast, broadcast and point-to-point, voice and record services. Are cable television and videotex, for example, appropriately regarded as broadcast media? Many of the current issues which affect the market potential and dissemination forecasts stem from this breakdown of old technological categories.

As early as 1949, the FCC allocated space on the broadcast spectrum to mobile radio, which competed with telephone./16 In 1959, non-telephone companies were allowed to use microwave frequencies for point-to-point transmission. Other companies were claiming that they could provide equipment charges. In 1968, in the Carterphone case, the FCC allowed non-AT&T equipment to be connected. In 1971, the FCC allowed new "specialized carriers" to offer private line services in competition to AT&T, and in 1972 it opened the domestic satellite to competitors. AT&T has fought all of these changes. The FCC has moved slowly, and this has been a brake on telematics development.

In international communications, the cables, the first of which were all British, were unchallenged for about 40 years. In 1901, Marconi first transmitted telegraph signals by wireless, but this was used mostly for ships at sea. The Marconi company was also British, and at the outbreak of World War I the U.S. Navy took control of these facilities in the U.S. In 1918, the Radio Corporation of America (RCA) was formed to take over and operate these facilities within the private sector./17

After World War II, transoceanic telephone, and later satellite communications, provided further alternatives to telegraph cables and radio. Both government policy and industry practice insisted on maintaining the economic viability of all of these modes to assure national security and reliability of communications./18

Market structure has also been the major public policy issue in international communications. The FCC in theory takes into account the benefits of competition in making entry decisions, but the Supreme Court has ruled that new services "must benefit the public," and that there must be enough traffic to sustain both old and new companies in allowing additional entries./19 FCC rate regulations encourage uniform rates and services. International record communications companies (IRCs) therefore present the appearance of a cartel; that is, a small number of companies with uniform services and rates and high entry barriers. Laying cables or sending up satellites is very costly, which further reinforces entry barriers.

In 1956, the first voice quality cable, TAT-1, was laid by AT&T and a PTT (European Postal/Telegraph/Telephone administrations). Later voice quality cables were also jointly owned. These modern cables also handle non-voice communications, i.e., record or telegraph messages, and are thus used by the IRCs which have a quasi-ownership interest in them. Responsibility for a message passes at midpoint of the cable from an IRC to a PTT./20

In 1943, Section 222 was added to the 1934 Communications Act. It prohibited Western Union from offering international services, and it prohibited the IRCs from offering domestic service, except delivery of international messages to clients in a very small number of "gateway" cities specified by the FCC. Western Union divested itself of Western Union International, which has since been an entirely separate company. The FCC allows AT&T to offer only all-voice service overseas. IRCs cannot offer all-voice

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EPA-287 (Cin.)
(4-76)

service, but they can transmit voice/data either simultaneously or alternatively over private lines, as well as providing cablegram and telex services./21

The INTELSAT satellite is owned by Intelsat Signatories, the U.S. signatory being COMSAT. The IRCs are half owners of the earth stations and lease a half-circuit from COMSAT—to the satellite, with the other half being leased by a PTT.

As of 1978, there were six IRCs: ITT Worldcom, Western Union International, RCA Globcom, TRT, and two much smaller companies. An FCC audit showed that the IRCs enjoy a very high rate of return: from 18.6% to 58.3% on telex services, and 19.6% on their private line services./22 This is the reason that there are a great many would-be entries into the international services market.

The IRCs, as already noted, can deliver messages directly to U.S. clients in only a few gateway cities; Western Union completes the deliveries to clients in other cities. However, in 1979 the FCC allowed Graphnet, Inc. to compete with Western Union for these services. The FCC also opened 20 more "gateways" in major cities for direct service by IRCs, and allowed Western Union in return to send telex messages overseas through Canada or Mexico rather than through the IRCs. However, Federal courts ruled that the FCC could not allow Western Union to do this because of Section 222. There is legislation pending to remove this barrier./23

Also in 1979, the FCC ordered IRCs to cease "bundling" their rates. This was a practice whereby the costs of terminals for private line customers, the costs of access loops and connections to IRCs at the gateway, and overseas rates were combined or bundled. This allowed the IRCs to provide the terminals for free, or nearly so, whereas Western Union was required to charge for terminals and local access loops./24

In April 1980, the FCC initiated a rule-making procedure to let COMSAT deal directly with the public rather than only with AT&T and the IRCs. The FCC also wants to remove barriers to IRC and AT&T re-sale of access and shared use of their leased circuits, to encourage new entries into the industry./25

In fact, four new entries had already been authorized, but their entry has been blocked by refusal of the PTTs to conclude cooperative agreements with them, concerning interconnections and division of revenues. The PTTs are willing to reach such agreements with AT&T and Western Union, but they fear that additional entries may fail, or that they will divert customers from the PTT's use-sensitive-rate services to private line services./26

Thus, the FCC is moving—albeit with agonizing slowness—to increase competition in both domestic and international services. This results from recognition that the new technologies, by breaking down old distinctions between modes, have made nonsense of many of the old regulations and restrictions and destroyed the case for "natural monopolies." The established providers of services are being challenged by many entities with proposed services and systems ranging from computer-based message systems to improved facsimile transmission systems and communicating word processing systems. For example, Xerox is proposing to establish a nationwide common carrier network called XTEN to offer high-speed digital communications. Satellite transponders leased from domestic satellite carriers would be used in connection with a terrestrial point-to-point microwave system to carry the signals between earth stations and city nodes, from which the electronic message system spectrum would carry them on to individual client locations.

Systems such as these will, of course, also strongly impact the U.S. Postal Service, creaming off the most lucrative portions of their business and leaving USPS with those delivery services which do not support their own costs. This could make rural delivery and journal/newspaper deliveries, for example, prohibitively costly.

Most experts believe that the end result of these changes will be dramatically lower costs for telecommunication services and a new wave of innovation in both services and equipment. Because the old boundaries between storing, manipulating, and transmitting data are breaking down, advances in telecommunication technology also means advances in all related information technologies, so that these issues—involving conflicting interests and objectives of multiple competing companies and technologies, and the underlying assumptions of the FCC, U.S. regulatory policy, and even other governments and international bodies—have implications for all of telematics in the future.

SOME IMPLICATIONS FOR EPA

The issues highlighted in this chapter are only a portion of the concerns of the dominant stakeholders in and out of government in the field of telematics. The thrust of those issues is overwhelmingly in the direction of market competition, accommodation to telecommunications regulatory constraints, propagandizing and lobbying for access to new markets, coping with problems at the technoeconomic level of convergent integrating technological systems. For other stakeholders, the concentration is principally on short-term economic consequences, job displacement, job upgrading. For others, the focus is principally on civil liberties, civil rights access, an agenda of issues coming out of a steady stream of economic concerns dominant in the mid-decades of the present century.

There is no prime actor in the telematic scene with a basic long-term perspective or concern for issues of health, safety, ecology, and transformations of and impacts upon the technoeconomy. Consequently, if EPA is to successfully engage a long-term anticipatory program of research on the environmental consequences of telematics, it must begin a systematic program of constituency building, broad-scaled but salient engagement of stakeholders, and emphasis on the value of early and timely investigation, monitoring, and resolution of potential problems before they burgeon into structural deficiencies in our complex society. The telematics technology itself will have very few direct effects. The major consequences will come from substitution and from the capabilities implicit in telematics as discussed at fuller length in Section 5. Consequently, these dominant effects are indirect, downstream, second order, and derivative of the primary factors driving legislators and regulators, the forces in the market. In order to cope with the major consequences of telematics foresight, images of the future, alternative goals and perspectives, and an integrated cooperative program of research and monitoring, perhaps accompanied by real world intervention experiments, is the only way to effectively engage this future.

EPA-287 (Cin.)
(4-76)

SECTION 7

FINDINGS AND CONCLUSIONS

1. The potential benefits of telematics to the economy, the environment, and to health and safety, are very large and numerous. Benefits will far outweigh the potential social costs.

   The benefits of telematics will extend over almost all facets of society. With regard to environmental quality and public health, telematics will strongly support detection, monitoring, and tracking of pollutants and advances in control technology both in the open environment and in the indoor environment. It will allow natural resource management, minerals development, and management of fisheries, herds, and forests to be done on a more environmentally sound basis. It will assist in international cooperation to attack global environmental problems. Telematics will provide advances in prevention, diagnosis, and treatment of diseases, including those which are related to environmental causes, and facilitate delivery of medical and disaster response services.

2. No government organizations or private sector groups are systematically planning to exploit the environmental benefits of the rapidly proliferating telematics technologies on a scale commensurate with their benefits.

3. Most of the benefits of telematics are likely in the long run to be provided by the private sector. The timely development of positive environmental applications and the prevention of environmental abuse by private initiative alone is far less certain. The most socially beneficial environmental applications should be developed and promoted by the Federal government, especially EPA.

   Industrial and commercial applications of telematics are likely to lead telematics development and marketing, with military and diplomatic applications also being a driving force. Continuing inflation, high interest rates, or public resistance based on unacceptable rates of employment displacement could be strong inhibitors of industrial/commercial applications. With or without such inhibitions, environmental applications may lag unless EPA is fully cognizant of the capabilities offered by telematics and urges their realization on industry, governments, and the public.

4. There are some potentially troublesome environmental and health impacts associated with telematics. Their significance is now uncertain. It is not in the self-interest or the legislative mandate of other major stakeholders and actors to call attention to and assess these potential problems. This implies an important role for EPA which is now being neglected.

   The four most important potentially undesirable impacts of telematics which are poorly understood are:

   - microwave radiation;
   - indoor pollution, ozone and other materials produced by telematics equipment;
   - solid waste disposal of toxic materials in telematics devices at the end of the use cycle;
   - human factors, design failures, and psychological and physiological stress in the modern telemated office.

   The most potentially important and socially divisive, and the most uncertain, potential problem is the effects of nonionizing radiation. Public concern, although not strong at present, is rising. EPA has delayed for several years in providing guidelines on microwave radiation and has not taken steps to provide the public with credible, useful information on the subject. Scientific knowledge at present is inconclusive. But there are already clear signs that local governments may act, in the absence of EPA exercise of responsibility, in ways which cause systematic problems for the nation and for future telematics development.

5. The failure of the Federal government and EPA particularly, to act in a timely, unequivocal, judicious manner on microwave radiation's effect could substantially inhibit the enormously productive application of telematics to the American economy, by encouraging the proliferation of vast numbers of incompatible local and state rules and ordinances.

   The adverse effects on the economy of equivocation and uncertainty would be a major economic setback. It should further be noted that in many of the applications where microwaves could be employed there is an alternative technology—fiber optics. Consequently, acting in an early and timely fashion would clarify productive development and innovation in the area of telematics.

6. Telematics is a facilitator rather than a primary driver in decentralization of population and industry.

   The future implications for environmental management of decentralization include changes in the nature and location of environmental impacts both positive and negative in effect, and complications in the detection, monitoring, and control of pollutants. EPA should now be doing strategic planning to adjust to these changes. Analysis shows that it is not in the self-interest of major actors in telematics development, not in the charter responsibility of Federal agencies primarily concerned with telematics, and not within the limited resources of organized public interest groups, to take the lead in anticipating and studying these potential problems. EPA is the logical agency to do so. EPA will need to understand and develop information exchanges with its latent constituency in this area and with the other stakeholders and actors.

7. Public support for environmental protection will fluctuate but is likely to remain strong, and to grow in the long run. Changes in national priorities and political attitudes will, however, require a more flexible and innovative strategy for carrying out EPA missions in telematics.

   Environmental concern is now fairly well institutionalized and buttressed in law, bureaucracy, support services, and organized constituencies. Surveys currently report continuing strong support for environmental protection despite the movement toward deregulation. Cross-national and global environmental problems are becoming international issues, with other countries concerned about the U.S. as a chief offender. Deterioration of the global environment will become more visible in the future. Public concern is likely to focus increasingly on environmental causes of disease as other sources of ill health are brought under control. Scientific capability to trace the link between pollution and health effects is also likely to increase. For all of these reasons, support for environmental protection is likely to remain strong in spite of short-term fluctuations in political priority.

   However, we are in a period of renewed assertion of regional, state, and local prerogatives vis-a-vis Federal programs, and reliance on detailed regulation and uniform standard setting as the sole or chief means of achieving environmental quality is under question.

8. The environmental problems and opportunities of telematics cut across the institutional lines within EPA and the jurisdictional lines of EPA and other Federal agencies.

These factors alone would suggest the need for new strategies and orientation toward coping with telematics opportunities and problems. A third and equally important factor, however, is that the nature of the problems, their origins, and presumably their remedies will not comfortably fit with the strategies developed in the 60s and 70s and therefore there is a major opportunity for innovation in the early and timely engagement of these problems with the private sector.

9. The best evidence is that telematics does not motivate people to reduce travel to any significant degree, other things being equal. But if travel is cut back for other reasons, telematics will moderate the social disruption and inconvenience which would otherwise occur.

The rising cost of transportation fuel is probably the strongest potential factor in reducing transportation needs; frustration arising from congestion and deteriorating transport systems could be another. In the absence of these factors, better communication probably encourages travel by enlarging the effective area of social and commercial relationships.

Telematics will permit some people, especially independent professionals, to work in their homes; and some large-scale information handling organizations may decentralize into smaller dispersed work units. In itself, there is little convincing evidence that this change would be large.

Reduction in commuting would be likely to have both beneficial and negative effects on city environments, reducing some sources of pollutants but eroding the tax base which supports environmental and public services. Working at home could increase the willingness to make financial and personal commitments to the home community, including environmental protection.

10. The telematics industries consume energy and materials in manufacturing and in providing services. In general, however, the industry itself appears environmentally benign.

Telematics industries appear to impose no unique environmental burden, and none comparable to some other industries which contribute as much in GNP, exports, employment, and technological leadership. The possibly significant exception could be microwave radiation, but scientific information on this subject, as already noted, is now inadequate and inconclusive.

11. The biggest effects from telematics will result directly from substitution and from new capabilities.

Examples of these effects are remote sensing, giving us the capability to anticipate crop yields around the world. Microprocessing will permit real-time, highly localized monitoring and control. Word processing will, by being a "black box" process, lend itself to unexpected uses.

12. A federal role with regard to telematics is necessary and inevitable, but it need not be and should not be a dominant role.

A Federal role is justified by the public resources invested in telematics over more than a century, and by the use of the public domain (e.g., the broadcast spectrum). Telecommunications, and in the future telematics, is critical to the functioning of government in a complex society, to military security, and to relationships between nations. Congress has recognized the absence of, and the need for, international communications and information policy. In a broader sense, telematics is clearly a form of commerce within the meaning of the Interstate Commerce Clause. However, since the 1830s development of telematics and its predecessors has been primarily within the private sector and should continue to be so.

This report argues that the Federal government should act when necessary to capture societal benefits which would otherwise be lost, and to avoid societal costs which would otherwise be unnecessarily imposed.

13. There are three classes of meta-impacts, which would result from the large-scale pervasive use of telematics in American society, each of which could in itself have far more important environmental impacts than any other effects we have come upon.

These are: a) Vulnerability to systems collapse. This can come about from terrorist actions, electromagnetic pulses, electric power failures, maintenance failures, and systems breakdowns. b) Technological failures, notably the lack of structures for the adequate synthesis of information. c) Politically related issues involving such matters as the value and price of information, privacy, and management of data bases.

14. EPA has a unique and necessary role to play in researching and assessing the potential positive and negative impacts on society of the telematics revolution.

If EPA is to successfully engage a long-term anticipatory program of research on the environmental consequences of telematics, it must begin a systematic program of constituency building broad-scaled but salient education of stakeholders, and emphasis on benefits and on the value of early and timely investigation, monitoring, and early resolution of potential problems.

15. The United States military and national security system is fully committed to telematics. The implications of that intensive involvement and dependency on telematics technology in peacetime, in a conventional war, or in case of a nuclear exchange, is outside the scope of the present study, but it is of such prime importance as to merit independent analysis.

SECTION 8

RECOMMENDATIONS

RECOMMENDATIONS TO EPA

The first group of recommendations coming from this assessment are intended for EPA (the sponsor of this assessment) and specifically for the Office of Research and Development. The report should also serve a larger audience. The final three recommendations involve actions in which EPA could not be the primary actor but should play a strong supporting role.

1. EPA should continue to expand its role in exploratory research and assessment of the societal implications and potential impacts of telematics.

   While this research and assessment should focus on the environment and public health, EPA's primary responsibility, it should not neglect the broader technoeconomic impacts, since changes in this sphere will have secondary impacts on the environment and public health which may in the long run be more important than more immediate direct impacts.

2. EPA should accelerate its address to the questions of microwave radiation effects and coordinate its work more tightly with the FCC, the Armed Services, industry, and others concerned with this matter.

   Although present scientific knowledge about non-ionizing radiation is far from conclusive, continued delay in clarifying policy actions opens the possibility of a gradually rising level of public disquiet which could become entrenched and reduce the credibility of later EPA guidelines. If there are sudden acute alarms, no matter how ill-founded, telematics could eventually face something of the resistance which nuclear power now suffers. Another possibility is precipitous regulatory action on a piecemeal basis by local jurisdictions, as was proposed in 1978 by New York City's Board of Health. EPA should press for funding for continuing and expanded microwave radiation research.

3. EPA should conduct further research and assessment on the impact of telematics on the indoor environment.

   Emissions of ozone from telematics devices, and toxic fumes from the devices if they are caught in office or residential fires, are of some concern.

4. The human factor elements in the telemated office and factory of the future will become increasingly pressing and urgent. Further research of the human factor considerations, including body shape and size, the body in motion, and the body at work, should be begun immediately in conjunction with NIOSH and representation from labor and industry.

   Once office designs and equipment patterns are frozen and widely used, it will be extremely difficult to bring about structural changes however important they may be. The human factors area is the clearest, most unequivocal opportunity for fresh initiatives which will have undeniably beneficial outcomes.

5. EPA should assess and monitor the ultimate disposal of telematic devices.

   Under present conditions, the presence of toxic substances in these devices is apparently not a problem because the manufacturer takes care of recycling or disposal. This is not a firm conclusion, because information on the subject is sparse. Safe disposal could be a problem in a telematics-intensive future, especially for local governments which may use disposal techniques inappropriate for the exotic substances in the devices.

6. To accelerate the positive use of telematics for environmental enhancement, EPA should exhaustively review, within the framework of its established programs and missions in air, water, solid waste, noise, and toxic substances:

   - the extent to which telematics are now used or available for environmental monitoring and control

   - specific needs and requirements which could be met, now or potentially by telematics

   - design criteria which would be necessary for telematics to fill such needs

   - the likely effects of more extensive telematics use in carrying out mission and program responsibilities

   - costs or cost savings from use of telematics

- internal or external inhibitors to use of telematics for environmental protection.

7. Information generated by this review should be systematically shared through a handbook and other information mechanisms, with:

    - telematics producers and service providers
    - industries looking for cost-effective ways to reduce their pollution
    - natural resource managers in Federal, State, and local agencies
    - environmental interest groups
    - the interested public.

8. As a short-term and highly productive stopgap measure, EPA could initiate a program to prepare software packages on environmental matters usable on mini- and micro-institutional and personal computers.

> The software package could be very useful in assisting the monitoring of energy or waste production. They could be conceptually oriented to promote the understanding of open issues, or they could have educational, recreational objectives to inform and delight.

9. EPA should take the lead in initiating discussions and joint studies with other agencies about the applications of telematics to their missions where the responsibilities of the other agencies have secondary environmental implications. Examples are:

    - Department of Interior—resource management, off-shore drilling, etc.
    - Department of Agriculture—farming and forest, crop and grassland management
    - Department of Commerce—weather prediction and warning of natural disasters
    - National Bureau of Standards—building standards and indoor environments
    - Department of Energy—pollutants from energy conversion
    - Department of Transportation—traffic control and emissions
    - National Institutes of Health—environmental diseases
    - Occupational Safety and Health—telematics workers, human factors

- Federal Emergency Management Agency—disasters and vulnerabilities
- Office of Science and Technology Policy—a national commission
- Department of Housing and Urban Development—home and office design and public policies for a telematics use.

BROADER FEDERAL RESPONSES TO WHICH EPA COULD MAKE A STRONG CONTRIBUTION INCLUDE:

1. A National Commission on Telematics Policy under Presidential or Congressional sponsorship should undertake to define the long-term national policy choices toward telematics.

   Where many interests are affected as with telematics, but no organization has responsibility or authority, the policy forces drive attention to the immediate and the parochial. The absence of goals encourages diffuse responsibility and piecemeal approaches. There are proposals in Congress to establish a commission or inter-agency task force to develop international telecommunications and information policy. The problem is broader than that. There are, however, models among the advanced industrialized nations demonstrating both the feasibility and the practical significance of nationally-based policy studies. The Nora/Minc study for the President of France, Telcom 2000 by the Austrialian government, and the work of the Secretariat for Future Studies in Sweden are partial models for what America needs to do.

   Many of the items recommended below could legitimately be subsumed under such a study. However, anticipating the worst, that such a commission would be slow in starting, the two following recommendations are put forward as if such a study were not to be undertaken.

2. A number of large-scale, real world intervention experiments should be planned and undertaken under multi-agency auspices with effective but not dominant participation by EPA. These experiments would help to determine the causes, behavior, and consequences of telematics. This information could guide public and private policy choices.

   The Mitre Corporation, almost a decade ago, began experiments of this sort in Reston, Virginia, but the nation needs a more comprehensive, up-to-date series of such experiments dealing at least with:

   - the office of the future
   - the telematics-intensive household

- the robotized factory
- natural resource management

These real world experiments would be an excellent opportunity for new, private sector government ventures in a collegial and cooperative approach to defining the system and the policy actions which will serve the public interest, promote national productivity, give an expanding role to the United States in world markets, and be socially and environmentally sound.

3. An inter-agency coordinating committee under the sponsorship of the Department of Commerce or NTIA or OSTP in the area of telematics would be a useful intermediate step toward clarifying policy choices and coordinating research and study activities.

One must recognize the limitations on inter-agency mechanisms. They primarily are limited to information coordination and exchange. Generally, interagency committees are weak with regard to policy formulation or effective direction. Their information transfer role reduces redundancy and protects bureaucratic turf. Within these constraints good is sometimes done.

The overall thrust of these recommendations is that EPA begin defining for itself a responsibility and task with respect to telematics which is well within its existing Congressional and Presidential mandate to protect the nation's environment, and which without EPA initiative will not be undertaken. In that case, potential benefits to the environment and to public health and safety may be delayed or lost, or unnecessary societal costs may be imposed. These recommended actions if taken would also begin to identify the latent constituency for EPA telematics assessments.

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EPA-287 (Cin.)
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APPENDIX A

ANNOTATED BIBLIOGRAPHY ON TELEMATICS

INTRODUCTION

The following bibliography was selected to represent the most important literature on telematics.* The scope is broad, including descriptive material on the various technologies and their applications; studies of the impacts on the environment, human culture and other technologies; related research and policy issues; and material about the development of telematics in other nations. Foreign developments are included even though the scope of the study is not international because of the impact of developments elsewhere on U.S. domestic policy.

While the scope is broad, every effort was made to keep the number of documents small. The set is intended to form a well-selected introduction to telematics for the policy-maker who has no particular technical background in the area. The ninety or so items would fill a shelf or two -- what one could assimilate in a couple of weeks. Some documents were included because they represent a genre, for example, Running Wild. Others represent important streams of research, the stance of important organizations, or the best summary of a particular area. Thus, under each general heading is an array of literature which varies in depth, complexity, and perspective.

The literature is organized into six areas: 1) comprehensive works, 2) descriptions of technologies, 3) impacts -- subdivided by focus of impact, 4) applications, 5) international -- subdivided by nation, and 6) research and policy issues.

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*Telematics is a new term for telecommunications, computational and information technologies, which are rapidly coalescing to form new information, analytic and control systems.

EPA-287 (Cin.)
(4-76)

I. COMPREHENSIVE WORKS

Arthur D. Little Inc. Telecommunications and Society: A Report to the Office of Telecommunications Policy, Executive Office of the President. Cambridge, Massachusetts: Author, June 1976.

This report gives the reader a sense of the impacts, both positive and negative, which may result from telecommunications. It includes five detailed scenarios on the future of telecommunications, each with its own introduction and commentary. These scenarios analyze the future of the Postal Service, citizens' band radio, broadband distribution to the home, consequences of broadband telecommunications technology, and the growth of a public service satellite system. The final chapter discusses factors such as industry structure, pressure group operation, and subsidization issues.

Bowers, R., A. M. Lee, and C. Hershey, eds. Communications for a Mobile Society: An Assessment of a New Technology. Beverly Hills, California: Sage Publications, 1978.

This book examines the implications of the expansion of mobile communications for commercial, private and public purposes. It includes several papers which discuss the development of mobile communication technologies; the environmental and health risks posed by the technologies; and the energy, transportation, economic, and political issues raised from their use. The issues of spectrum allocation, impacts on work patterns, and potential legal problems of privacy, liability, and individual freedom are also discussed.

Dertouzos, M. L. and J. Moses, eds. The Computer Age: A Twenty-Year View. Cambridge, Massachusetts: MIT Press, 1979.

This book explores trends in the development of computer technology and examines many of the potential human, social, and economic impacts from these trends. Written for the general reader, several of the articles look at the future applications of computers in homes, education, business, and scientific work. Other articles in the book discuss the socioeconomic framework for computer development. They include essays on centralization and decentralization, regulation, economics of information, and world affairs as impacted by computers. Written by experts in their respective fields, the book provides an incisive and thorough analysis of key issues in computer development.

Evans, C. The Micro Millennium. New York: Viking Press, 1979.

This book projects to the year 2000 the advancements in computer technology and their transforming impacts on society. Written for the layperson, it examines the impacts of short, medium, and long-term future developments in computer technology with

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an emphasis on the political and social changes that are likely to occur. Predictions include the collapse of the work ethic, the erosion of the power of the professionals, the coming of the cashless society, and the reevaluation of intelligence with the development of ultra-intelligent machines. The book begins with a brief discussion of the evolution of computers, their present state of development, and the driving forces behind the coming change.

Martin, J. The Wired Society: A Challenge for Tomorrow. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1978.

The author writes a stirring account of what life would be like with the rapid development of telematic technologies. Using non-technical language, the author describes the possible effects of the increased use of telematics on shopping, banking, work, education, government, and social organization. He views the development of telematic technologies as an important means of solving resource problems and improving the quality of life.

McHale, J. The Changing Information Environment. Boulder, Colorado: Westview Press, 1976.

This book focuses on the impacts on the structure of society from large-scale development of electronics and computer technology. It describes the evolution and convergence of computers and communication technologies and the potential changes in social values and institutions as information and knowledge become important resources. The book probes the impacts on individual capabilities, business, education, management, and the political process. Global impacts and policy issues are also discussed.

Moss, M. L. Telecommunications and Productivity. Reading, Massachusetts: Addison-Wesley Publishing Company, Inc., 1981.

This book explores the effects of new telematic systems on productivity in business and government. It examines the role of the public and private sector in telematics policy-making and analyzes emerging trends in the use of telematic systems with specific case studies drawn from private industry and public agencies. The book provides an excellent summary of the latest happenings in telematics.

Mowshowitz, A. The Conquest of Will: Information Processing in Human Affairs. Menlo Park, California: Addison-Wesley Publishing Company, 1976.

This book probes the diverse impacts of information processing systems on society. It looks at the forces underlying the growth of computers, their impact on industry, corporate

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decisionmaking, work and education, and their future role in politics and social control. The consequences for individual attitudes, values, and perceptions are discussed. The book is concerned primarily with the impact of telematics on the distribution of power in society.

Nilles, J. M. A Technology Assessment of Personal Computers (3 vols.), Los Angeles, California: Office of Interdisciplinary Programs, University of Southern California, 1980.

This technology assessment explores the future growth of personal computers and related industries, the potential impacts and consequences of that growth and the public policy issues that could result. The assessment describes the many possible applications of the new computers, the alternatives to personal computers, and some of the socioeconomic trends that could influence their growth and application. Public policy implications in the areas of education, employment and international trade are comprehensively described. Many references are included.

Office of Technology Assessment. A Program in Telecommunications, Computers, and Information Policies: A Tentative Agenda for the Office of Technology Assessment. Washington, D.C.: Author, 1977.

This document proposes an agenda for OTA for a program in telecommunications, computer, and information policies that focuses on an initial set of projects. These projects include studies of: the U.S. Postal Service and electronic message service; the problems of privacy and security; the future of mobile radio; and alternative futures for television broadcasting. Appendix A discusses at length significant issues raised by the report including: communication and information policy formation and coordination; the economics of communication and information services; regulation and competition, monopoly and restraint of trade; and innovation and standardization. Appendix B probes conflicts in telecommunications among telephone carriers, suppliers, and specialized common carriers.

Osborne, A. Running Wild: The Next Industrial Revolution. Berkeley, California: McGraw-Hill, Inc., 1979.

This book, written for the layperson, describes the development of microelectronics and the likely impacts on society of future advancements and applications. The book focuses on the development of computers and robots and their implications for manufacturing, office work, and home life. It provides the reader with a basic understanding of how the technologies work and their potential vulnerabilities to crime and misuse.

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Robinson, G. O., ed. Communications for Tomorrow: Policy Perspectives for the 1980s. New York: Praeger Publishers, 1978.

This book examines in a comprehensive manner the social, economic, and legal implications of new telematics technologies and the policy options which they present. It explores general social, economic, and technological trends in communication services and facilities; key issues of industry structure and regulation affected by those trends; and the capabilities of government and institutions to address emerging policy issues. The book also looks at new social service applications and their impacts on present communication systems. The book provides a well-written and thorough discussion of telematics.

II. TECHNOLOGIES

Bejczy, A. K. Sensors, Controls and Man-Machine Interface for Advanced Teleoperation, Science, 1980, 208 (4450), 1327-35.

This article summarizes the state of the art in teleoperation--mechanical manipulation under remote control. It provides a brief outline of problems in teleoperation development and presents the results of research at the Jet Propulsion Laboratory. The article includes in its discussion the development of dexterous articulated mechanisms, smart sensors, flexible computer controls, intelligent man-machine interfaces, and innovative system designs for advanced teleoperation.

Carl, C., R. S. Cowdery, and R. K. Granit. Public Service Communications Study. Pasadena, California: Jet Propulsion Laboratory, 1975.

This report presents JPL's forecast of the future of industry and government telecommunications technology and services over the next ten years. The trends and forecasts as well as the current status of several technologies including broadband cable systems, data-processing, land mobile communications, satellite, wire telephony, and optical communications are described. The report, which is technically oriented, also provides information on current user patterns.

Convey, H.D. and N. H. McAlister. Computer Consciousness: Surviving the Automated 80s. Reading, Massachusetts: Addison-Wesley Publishing Company, 1980.

This book provides a layperson's overview of the technical development of computers and an introductory presentation of computer machinery and programming. The book attempts to help the user gain a general understanding of the way in which computers function and how they can be used for maximizing results. The book focuses on business applications of computers.

EPA-287 (Cin.)
(4-76)

Credit Cards Get a Lot Smarter, Business Week, February 23, 1981, 107-114.

This article describes the latest developments in credit card technology; specifically the development of cards which contain an imbedded integrated circuit. The debate over new "cards with a memory" is discussed in terms of increased capabilities for keeping track of transactions, the potential for increased security, and the enormous installed investment in magnetic stripe cards. The French and Italians are leading the way in testing the new cards, although various U.S. companies are developing both new technologies and improvements in magnetic tape for use in credit cards and other applications, such as door keys.

Crombie, D. D., ed. Lowering Barriers to Telecommunications Growth. Washington, D.C.: Science and Technology Telecommunications Task Force, U.S. Department of Commerce, 1976.

This report examines in detail the current status of four major telecommunications technologies: direct satellite communications, land mobile radio, broadband communications networks, and fiber optic communications, and the issues and barriers affecting their growth. The discussion of each technology considers its needs and market, the systems development and performance, policy and regulation, and spectrum management. The report proposes a series of policy actions.

Dolotta, T. A., et al. Data Processing in 1980-1985: A Study of Potential Limitations to Progress. New York: John Wiley and Sons, 1976.

This book attempts to predict the environment and status of the data processing industry in the years 1980 to 1985, with emphasis on large, general-purpose, business-oriented data processing systems. It discusses user expectations over this period and how and why they differ from the way the industry is likely to develop. The book deals extensively with trends and issues in hardware and software, applications, and the management of data processing systems. Several recommendations are offered for improving productivity, usability and management of data processing systems.

Eikonix Corporation. Technology Assessment: The Impact of Robots. Burlington, Massachusetts: Author, 1979.

This technology assessment forecasts the development of robotic technology. It studies robotics, potential applications and impacts in households, the nuclear industry, and manufacturing, and evaluates the policy alternatives which could influence these impacts. The assessment includes interviews with manufacturers, researchers, and users of robotics and an

EPA-287 (Cin.)
(4-76)

assessment of robotics in Japan. Policy options are evaluated in terms of basic research funding, income redistribution, energy use, employment dislocation, and productivity.

Martin, J. Future Developments in Telecommunications. Second ed. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1977.

This book provides a comprehensive technical description of the evolution and future trends in telecommunication technologies for the lay reader (Parts I & II), and for the technical reader (Part III). The book takes the reader step by step through the development of the various technologies and discusses the implications of telecommunications for the home, national politics, law, and international relations. The book is appropriate for those wanting an in-depth understanding of how the technologies work.

National Research Council. Science and Technology: A Five-Year Outlook. San Francisco: W. H. Freeman and Company, published in collaboration with the National Academy of Sciences, 1979.

This document, which is a report to Congress on emerging scientific and technical developments, looks at future trends in computers and communications. Its discussion includes a description of current communication technologies and systems, a discussion of software problems and techniques, and a projection of future capabilities and trends. Questions of efficiency and cost are examined with each technology. Technologies and trends are described in satellite communications, optical fibers, robotics, home computers, electronic funds transfer, and other systems. Besides providing an excellent, condensed overview of telematics, the book has valuable information on U.S. demography, health and emerging developments in biology, materials, and toxic substance research.

Turn, R. Computers in the 1980s. New York: Columbia University Press, 1974.

This book explores the technical advancements in computers which are likely to occur in the coming decade. Among the hardware developments projected are the use of lasers in computer memory, and technical advancements in: processing speeds, computer architecture, storage capacity, terminal equipment, and times of random access. The first section outlines the techniques of technology forecasting; the second projects computer technology advancements; and the third develops a methodology to enable the reader to update projects.

Wise, K. D., K. Chen, and R. E. Yokely. Microcomputers: A Technology Forecast and Assessment to the Year 2000. New York: John Wiley and Sons, 1980.

This book forecasts the future of microcomputer technology and its impacts on society for the period 1976-2000. The book focuses largely on technical trends in microcomputer development and on some of the socio-economic forces affecting these trends. A detailed description of the impacts of microcomputers on aviation is presented. This book is appropriate for people interested in technology forecasting and the more technical aspects of microcomputer technology.

III. IMPACTS

A. General

Abshire, G. M., ed. The Impact of Computers on Society and Ethics: A Bibliography. Morristown, New Jersey: Creative Computing Press, 1980.

This bibliography contains 1,920 entries describing magazine articles, news items, books and scholarly papers dealing with computers and society. Most of them are short articles describing the development and application of computer technologies in business, government and social institutions. It is arranged in one sequence by author and covers the period 1948 to 1979. No information concerning the scope or selection process is provided.

Bowers, R., A. M. Lee, and C. Hershey, eds. Communications for a Mobile Society: An Assessment of a New Technology. Beverly Hills, California: Sage Publications, 1978.

See annotation on page 3.

Mayo, L. H., et al. An Exploratory Technology Assessment of Computer Assisted Makeup and Imaging Systems (CAMIS). Washington, D.C.: Program of Policy Studies in Science and Technology, George Washington University, 1980.

This report assesses the potential impacts and public policy issues from the development of CAMIS technologies. CAMIS technologies include word processors and office printers, fully automated printing processes, intelligent copiers, computer printers and plotters, facsimile terminals, image scanners, and optical character recognition devices. Among the many impacts examined are the effects on media, copyright and privacy, government information and printing, industry concentration and competition, employment, potential information overload, and anticipatory versus remedial government action.

EPA-287 (Cin.)
(4-76)

B. Economy

Porat, M. U. The Information Economy. An invited article submitted to the Scientific American. Institute for Communication Research, Stanford University, 1976.

This paper documents the transition to an information economy in the U.S. and analyzes the relationship between the information sector and the rest of the economy using input-output techniques. It deals quantifatively with trends in information occupations and work force, the relationship between information activity and GNP, and the distinctions between primary and secondary information industries. The article suggests ways in which national accounting concepts could include an "information sector."

C. Electronic Funds Transfer

Humes, Kathryn H. The Checkless/Cashless Society? Don't Bet On It! The Futurist, October 1978, 301-306.

In this article a senior staff member of the National Commission on Electronic Funds Transfers discusses why fully electronic banking has not yet happened, and why it seems unlikely in the future. While the capabilities for a "checkless/cashless" society exist, consumer skepticism and resistance remain as large barriers to fully automated banking. Electronic funds transfer systems, automatic teller machines and automated clearinghouses for credit checks have, however, already increased the efficient use of paper. The article is useful for anyone wishing to know the hardware currently used in the industry and its possible implications.

National Commission on Electronic Funds Transfers. EFT in the United States: Policy Recommendations and the Public Interest. Washington, D.C.: Author, October 1977.

This report extensively examines a variety of public policy issues caused by the development of electronic funds transfer technology. Consumer related EFT issues include questions of privacy, financial control, consumer rights, and liabilities. Business issues include impacts on the nation's banking system, the competitive relationship among financial institutions, and the future for small institutions. The report also examines the security and credit implications of EFT and the role of the federal government in EFT development and monetary policy.

EPA-287 (Cin.)
(4-76)

D. Environmental Health

David, L. A Study of Federal Microwave Standards. McLean, Virginia: PRC Energy Analysis Company, 1980.

This report assesses the role of the regulatory process in setting standards for permissible levels of microwave radiation exposure. The report summarizes current scientific knowledge of the health effects of microwave radiation and offers several explanations as to why standards differ in the U.S. and East Europe. The implications for the Solar Power Satellite are presented. It examines the need for studies which assess the effects of long-term, low-level microwave exposure.

Michaelson, S. M. Human Exposure to Non-ionizing Radiant Energy--Potential Hazards and Safety Standards, Proceedings of the IEEE, 1972, 60 (4), 389-421. (Institute of Electrical and Electronics Engineers)

This article reviews the biomedical impacts of exposure to ultraviolet, infrared, laser, microwaves, radio-frequency radiation, and the protection guides which have been established. The article explores the difficulty of standard setting, monitoring latent effects, and sorting testing variables. While somewhat dated, it provides detailed information on health risks from specific telecommunications technologies.

Michaelson, S. M. Microwave Biological Effects: An Overview, Proceedings of the IEEE, 1980, 68 (1), 40-49. (Institute of Electrical and Electronics Engineers)

This article provides a scientifically comprehensive assessment of the studies to date on the effects of microwave energy on the neural and immunologic function in man and animals. It evaluates the methodology and findings of previous studies and identifies areas of uncertainties for future research.

National Institute for Occupational Safety and Health, Division of Biomedical and Behavioral Science. Select Research and Reports on Health Issues in Video Display Terminal Operations. U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, NIOSH, Division of Biomedical and Behavioral Science, Cincinnati, Ohio 45226, April 1981.

This report is important because it is one of the first major projects on the health impacts of video display terminals (VDT's) to be done in the U.S. The three reports contained in this document are preliminary sections of a final report which will be available in the fall of 1981. Research was initiated at the request of a consortium of unions in the San Francisco area "which sought an evaluation of the impact of video display work on employee health". The first paper

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investigates worker stress and physical health complaints. The second paper focuses on design factors of the workplace--illumination, glare from the VDT screen, noise levels, and so on. The third paper covers radiation levels and chemical agents in the work area. Overall the reports found stress complaints were the result of job pressures interacting with the use of VDT's, particularly in the case of clerical operators. Design problems in both workplace and machine were found, and recommendations made. Radiation and chemical agent levels were found to be below safety-standard levels.

Sheridan, T. B. Computer Control and Human Alienation, Technology Review, October 1980, 61-73.

This article describes the psychological and human impacts of the spread and development of computers in society. The article discusses seven factors leading to alienation from computer use. They include mystification, increasing remoteness from actual production, reduction of skill level, concern over job obsolescence, and the threat of superior intelligence. The author argues that uniquely human capabilities of adaptiveness, creativity, and knowledge of subtleties should be used to complement the increased memory and calculation powers of the computer.

U.S. Environmental Protection Agency. Research Outlook 1980. Washington, D.C.: Author, 1980.

This report--EPA's five-year research plan--contains a well-written concise description of current information on the biological, health, and environmental impacts of non-ionizing radiation. It also provides detailed information on regulatory trends governing exposure levels and on research currently in progress. The report identifies some of the important unanswered questions concerning non-ionizing radiation exposure.

Weizenbaum, J. Once More--a Computer Revolution, The Bulletin of Atomic Scientists, September 1978, 12-19.

This article examines some of the weaknesses of computers when used to aid and replace human thinking and decisionmaking. The article focuses on the implications of the inability of computers to replicate personal kinds of knowledge, human reflections, and an individual's weltanschauung. The article discusses the problems of placing too much authority and confidence in computer models and their results. Several computer goofs are described.

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E. Legal

Freed, R. N. Computers and Law, a Reference Work. Boston, Massachusetts: Roy N. Freed, c/o Powers & Hall, 1976.

This multi-part reference tool--a compilation of more than 100 papers--covers almost all aspects of computers and the law through case studies and essays. Topics include liability, problems of evidence and proof, protection of data bases and proprietary programs, antitrust laws, and regulations. It also examines the use of computers in the judicial, legislative, and administrative processes.

Nycum, S. H. and D. B. Parker. Six Papers on Legal Issues and the Computer. Menlo Park, California: Stanford Research Institute, 1975 and 1976.

These six papers examine in detail legal issues raised by computers. Parker looks at the common characteristics, occupations, and modus operandi of computer criminals as well as the different vulnerabilities of computer systems and user organizations to computer theft. He develops a typology of the problem in order to assess the nature and growth of white-collar crime. Nycum's papers examine the relative criminal sanctions of various laws--State penal laws, the Federal Criminal Code and the Privacy Act of 1974--to criminal abuse. She also looks at the question of legal protection of proprietary rights in software.

F. Labor

Communication Workers of America. Technology--Its Impact on CWA Today and Tomorrow. The 1979 Conference: A Final Report. Washington, D.C.: Communication Workers of America, 1979.

This report summarizes the discussions of the CWA on the trends in telecommunications development and their impact on jobs, industry structure, management, and working conditions. The bulk of the report summarizes participant response to the direction and effect of industry growth. This is preceded by a general overview discussion of the importance to workers of anticipating technological change and monitoring impacts.

Kendall, P.M.H., et al. Chip Technology and the Labor Market. London: Metra Consulting Group, 1980.

This report assesses the international job and skill impacts of microcomputers. By reviewing the literature and by interviewing experts from around the world, the authors summarize existing information on impacts in certain areas of employment and skills. Areas covered and qualitatively ranked according to

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level of impact include manufacturing, office automation, telecommunications, and data processing. Areas identified as less important include banking and insurance, printing and publishing, education, hotels, retailing/point of sale, and transport operations. The report identifies information gaps covering quantified data on impacts and macro-analysis of the effect of computers on overall level of employment.

Norman, C. Microelectronics at Work: Productivity and Jobs in the World Economy. Worldwatch Paper 39. Washington, D.C.: Worldwatch Institute, 1980.

This paper warns of the potential mass job reduction from the proliferation of the microchip. It covers several aspects of microprocessor technology including a layperson's description of the technology, its development, and refinement over the last several decades, and its widespread application in industries, offices, and homes. The paper examines international competition among microelectronic industries and the consequences of microchip hegemony for North/South relations and Third World development. Also, the need for advanced policy planning to deal with future worker upheavals is discussed.

G. Office

Gehring, R. L., E. F. Murphy, and A. J. McGill. The Office as an Information System, Forbes, March 30, 1981.

This article presents the viewpoints of three corporate executives on the office of the future as an information system. Gehring, from Sperry Univac, examines the impact of computers on corporate management and organization. He discusses the importance of selecting the appropriate computer for the task and describes the possible improvements in manufacturing from the use of computers. Murphy, from RCA, discusses the need for organizing and integrating information among domestic and international systems and the general problems of system and equipment compatibility. McGill examines the role of telematics in improving management productivity and reducing communication barriers in the office.

H. Postal Service

Anthony, R. W., et al. Strategy for Decisions: APWU and the Electronic Information Revolution. Washington, D.C.: Program of Policy Studies in Science and Technology, George Washington University, 1980.

This report, prepared for the American Postal Workers Union, explores the implications of electronic technology for the U.S.

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Postal Service and the nation. The report describes the differing ways in which the private sector and the USPS view electronic mail; the potential conflicts of interest between telecommunications carriers and electronic message carriers; and the benefits and drawbacks of the development of EMS in the competitive marketplace.

Commission on Postal Service. Report of the Commission on Postal Service. Washington, D.C.: Author, April 1977.

This report briefly summarizes the impacts of electronic communications on the Postal Service. The report draws heavily from two studies by Arthur D. Little and the George Washington University's Program on Policy Studies in Science and Technology to forecast relevant technology developments and to estimate future rates of mail diversion. The Commission's short-term and long-term recommendations are included.

I. Transportation

Crosby, Robert W. Transportation, Communication and Societal Structure. U.S. Department of Transportation, Research and Special Programs Administration, 1980.

This paper illustrates the complexities involved in the question of a transportation/communications substitution. It approaches transportation and communications interactions in terms of effects on societal structures. Crosby describes social structures as single-level or multi-level, the difference being that single-level structures arise from "the interaction of otherwise independent elements", and are thus not hierarchical.

de Sola Pool, I. Communications Technology and Land Use, The Annals of the American Academy of Political and Social Science, 1980, 451, 1-13.

This article provides a broad overview of the historical relationship between transportation and migration patterns into and out of the city and telecommunications technologies. It describes the centripetal effect of telecommunications at the turn of the 20th century and its centrifugal effect in the middle of the century. The article also looks at some general implications of the energy shortage and recent telecommunication innovations on urban migration patterns.

Friedman, K. M. Telecommunications and Transportation Energy Demand: Opportunities and Caveats, Energy Communications, 1977, 3 (6), 555-600.

This paper analyzes in more technical detail existing theories and research findings on the transportation/telecommunications

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tradeoff for personal and business air and auto travel between and in cities. Estimates of the potential substitution and energy savings are made. Several caveats, constraints, and incentives for substitution are discussed.

Friedman, K. M. and R. M. Oberman. Transportation and Telecommunications; the Energy Implications, Annaul Review of Energy, 1979, 4, 123-145.

This paper provides a concise yet thorough analysis of the implications of telecommunications for transportation and energy demand. The paper summarizes studies assessing the impacts of telecommunications on intercity air travel, intercity automobile trips, urban passenger travel, and work decentralization. The paper also describes the telecommunications industry and the incentives and impediments for institutional use of telecommunications.

Harkness, R. C. Technology Assessment of Telecommunications/Transportation Interactions. Menlo Park, California: Stanford Research Institute, 1976.

This technology assessment examines the impacts from present and future interactions between inner and intercity business travel. A number of scenarios describing the possible interactions and their costs and benefits are postulated. Their results are examined in a series of impact papers which look at the effects of telecommunications on urban land use, public services and human/social conditions. Public policy implications are presented.

Nilles, J., F. R. Carlson, Jr., P. Gray, and G. J. Hanneman. The Telecommunications-Transportation Tradeoff: Options for Tomorrow. New York: John Wiley and Sons, 1976.

This book explores the possibilities and implications for substituting telecommunications for urban and intercity business travel. Case studies examine the costs and benefits of business decentralization, such as telecommunications capital costs and business moving expenses, and describes the steps a business would take in decentralizing. Energy comparisons are made between private auto commuting, mass transit commuting and telecommuting. Implications for the national energy demand are described. The book also explores the perceptions and attitudes which would influence substitution.

Obermann, R., M. Zobrak, D. Kutnick, and M. Dartch. The Impact of Telecommunications on Transportation Demand Through the Year 2000. McLean, Virginia: MITRE Corporation, 1978.

This report focuses on the future impacts of telecommunications on urban and intercity passenger travel. It examines in depth the development of four major telecommunication services--voice, video, data, and interactive cable T.V.--and the degree to which they can substitute for travel. Background information on the present and future telecommunication technologies, market, and institutional environment is provided. Several policy implications are discussed. There is an extensive bibliography included.

Overby, C. M. New Patterns of Work Organization in an Information and Computer-Telecommunications Era. Athens, Ohio: Industrial and Systems Engineering Department, Ohio University, 1974.

This paper summarizes the many potential uses of videophones and cable television services and comments on their potential impacts on intercity and urban transportation, work organization and location, energy demand, and urban development. The paper highlights the findings of several researchers in the field including Reid, Harkness, Dickson and Bowers, Sheridan, Lope and Goldmark, and Crane.

Reid, A. What Telecommunication Implies, New Society, December 1971, 1284-6.

Using historical trends, this article examines the impacts of telecommunications on office location and business travel in Britain. The article describes the trend toward reducing business travel through substitution and thr trend to increasing business travel through business stimulation. The article identifies several areas for future research.

Webber, M. M. Social Contexts of Transportation and Communication. Berkeley, California: Institute of Urban and Regional Development, 1978.

By using the example of the automobile and telephone, this article explores what it calls the profound interactive relationship between communications, transportation, and the general structures and functions of society. Of particular concern is the impact of communications and transportation on deprived social groups. The article calls for communication and transportation policies to be directed toward the development goals of regions and nations.

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IV. APPLICATIONS

A. Computerized Conferencing

Hiltz, S. R. Communications and Group Decision-making: Experimental Evidence on the Potential Impact of Computer Conferencing. Newark, New Jersey: New Jersey Institute of Technology, September 1975.

This study reviews experiments which examine the relationship of communication processes involved in computer conferencing to group decisionmaking and problem solving. The report attempts to identify research conclusions on the social effects of computer conferencing and the strengths and weaknesses of computer conferencing in facilitating group decisionmaking. The report also describes software information necessary for a non-programmer social scientist to conduct similar experiments. The study focuses on research methodology.

Hiltz, S. R. and M. Turoff. The Network Nation: Human Communication Via Computer. Reading, Massachusetts: Addison-Wesley Publishing Company, 1978.

The book provides an intriguing, comprehensive, and non-technical view of the emergence of computerized conferencing. While the book discusses in detail the development of computerized conferencing, its forte is in its exploration of the social and human implications of the technology. The book examines psychological impacts of computerized conferencing as well as the impacts on privacy, public participation, and the gap between the information rich and the information poor.

Johansen, R., J. Vallee, and K. Spangler. Electronic Meetings: Technical Alternatives and Social Choices. Menlo Park, California: Addison-Wesley Publishing Company, 1979.

This book takes a critical look at the potential advantages and disadvantages of audio, video, and computer-based teleconferencing. The book identifies future technological possibilities and uses a series of eight imaginative story-like scenarios to illustrate these possibilities. Each scenario probes the way in which each medium can be used effectively and ineffectively, and helps the reader draw conclusions about future uses of telecommunications. Two hundred references are included.

Vallee, J., et al. Group Communication Through Computers. 3 vols. Menlo Park, California: Institute for the Future, 1975.

This document describes the design and evaluates the capabilities of a group communication system called FORUM. It describes a social assessment methodology to evaluate the cost effectiveness and efficiency of computer conferencing in general, and its impact on the user. Volume III analyzes the pattern of use of FORUM among scientists and engineers. Five styles of computer conferencing are evaluated and several future scenarios are developed to explore potential impacts on government, public and private organization, business, and scientific disciplines.

B. Office and Home

Bunnell, D. Personal Computing: A Beginner's Guide. New York: Hawthorn Books, Inc., 1978.

This consumer's guide to personal computers focuses on the applications of computers for home and business use. The book describes in easy to understand terms how computers work and the many tasks they can accomplish, including time and money budgeting, storing business records and recipes, analyzing stocks, controlling utilities, balancing checkbooks, and educational and recreational games. The book compares the advantages and disadvantages of different computer systems and models for different purposes.

Cecil, P. B. Word Processing in the Modern Office. 2nd ed. Menlo Park, California: Benjamin/Cummings Publishing Company, 1980.

This book provides the computer buyer with an understanding of how world/information processing systems can be used in the office setting. The book describes the development of several different office technologies and how the most current, sophisticated technologies work. The technologies discussed include word processing keyboard equipment, copying systems, electronic data processing, and the latest office communication networks. It also provides information on selecting appropriate office equipment.

Freiberger, S. and P. Chew, Jr. A Consumer's Guide to Personal Computing Microcomputers. 2nd ed. Rochelle Park, New Jersey: Hayden Book Company, Inc., 1978.

This consumer's guide provides an introduction for the layperson to microcomputer systems for use in business, education, recreation, and the home. The book includes a product guide, a discussion of the advantages and disadvantages of specific systems, and best-buy tips for different microcomputer products.

Sumner, C. and W. A. Leavy, eds. Microcomputers for Business. New York: AMACOM, 1979.

This book, written for the businessperson, describes the versatility and capabilities of microcomputers by using several different case studies of small businesses using computers. For example, it looks at the use of computers in a small real estate

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firm, an auto parts store, a mortgage company, a clothing company, a farming cooperative, and an air freight company. The various applications discussed cover inventory, accounting, order entry, and payroll systems. In comparing systems, the book looks at initial and on-line expenses, hardware and software issues, and the different applications of multiprogrammable systems.

C. Social Services Delivery

Anthony, R. and J. F. Coates. Telecommunications and the Quality of Life in Rural America. Washington, D.C.: Office of Technology Assessment, 1976.

This unpublished report examines in-depth public policy issues concerning the effective application of telecommunications to the needs and opportunities of rural America. The report includes a primer on telecommunication technologies, a description of their services and functions, and an analysis of inter-industry competition and government regulation. The report assesses the potential of telematics for several aspects of community life in rural America, including health, education, aging, employment, mobility, migration, and community organization.

Appalachian Regional Commission. Appalachian Education Satellite Project Operation Plan. Washington, D.C.: Author, 1976.

This report describes the AESP Experiment to determine the feasibility of delivering educational courses via satellite (ATS-6 HET Communications Network) to sparsely populated areas in Appalachia. The report looks at the cost-effectiveness of the project in strengthening local education programs and describes the network design, operation, and programming of the project for 1980 and beyond. Included in the appendix are comments on the technical and economic issues concerning the continued use of the ATS-6 HET Communications Network.

Cowlan, B. and D. Foote. A Case Study of the ATS-6 Health, Education, and Telecommunications Projects. Washington, D.C.: Office of Education and Human Resources, Agency for International Development, 1975.

This paper reports on a series of experiments in the U.S. in 1974-75 on the delivery of educational and social services via satellite. It describes the space and terrestrial technology involved and the activities of each experiment, and examines a number of issues that came up during the experiments, including hardware, management, and software problems. Some of the experiments described include Rocky Mountain Education Satellite Project, Alaska Education Project, and the Alaska Indian Health Service Project.

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Kay, P. and S. Gerendasy. Social Services and Cable T.V. Washington, D.C.: U.S. Government Printing Office, 1976.

This report addresses the question of how cable television can be used to improve the delivery of social services. The report summarizes the results of seven studies using interactive cable television for social service delivery. It reviews the significant literature in the field and presents an overview of the social and administrative uses now being made of cable television. The book may be useful to those who want to know how cable television or a particular cable system can be used. An extensive bibliography is included.

Korman, F. Innovations in Telecommunications Technology: Implications for Education. Austin, Texas: Center for Communication Research, University of Texas, 1971.

This report provides a somewhat dated but comprehensive look at trends in telecommunications technology and their implications for education. Telecommunication systems and technologies such as public broadcasting, closed-circuit T.V., video tape recording/ cassettes, satellite, cable T.V., and radio are described with an analysis of their future trends and implications for education.

Mills, W., G. Kolsrud, and L. Turnbull. The Feasibility and Value of Broadband Communications in Rural Areas: A Preliminary Evaluation. Washington, D.C.: Office of Technology Assessment, 1976.

This report explores the feasibility and value of employing broadband communications to deliver public and commercial services to rural areas. The report identifies the constraints and impacts of widespread implementation of broadband communication technologies in rural areas and discusses the ways in which broadband technologies could help rural development. The evaluation includes a systems approach to assessing the role of broadband technologies and a discussion of policy alternatives.

National Research Council. Telecommunications for Metropolitan Areas: Near-Term Needs and Opportunities. NTIS Report # NRC/TELECOM/ 77-1. Washington, D.C.: National Academy of Sciences, 1977.

This report ecaluates evolving telecommunications technologies in relation to metropolitan needs. The report describes several urban telecommunication technologies and networks, and examines the costs and benefits of using telecommunications in business, city government, administration, health, education and welfare services, citizen safety and emergency, and mobile services.

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Park, B. An Introduction to Telemedicine. New York: Alternative Media Center, New York University, 1974.

This report describes in detail the history of the use of interactive television in health care delivery. It examines the physical, psychological, and cultural aspects of human communication via interactive T.V., and the current and pending telemedicine projects throughout the country. The report includes studies of the acceptance and capabilities of telemedicine in various fields of medicine.

Practical Concepts, Incorporated. Telecommunications: A Mechanism for Improving the Cost-Effectiveness of Social Service Delivery. Washington, D.C.: Author, 1975.

This brief report develops several service delivery models to evaluate the cost-effectiveness and efficiency of telecommunications-mediated social services. The report looks at health, education, and agricultural delivery models.

Tate, C., ed. Cable Television in the Cities: Community Control, Public Access and Minority Ownership. Washington, D.C.: The Urban Institute, 1971.

This book serves as an information and reference guide to increase the access and opportunities of minority groups in cable television. The book describes the importance and potential of cable for minorities, cable television equipment and facilities, and the obstacles for minority groups to gaining access and control. It examines the municipal regulations governing cable television and lists the federal, public, and private organizations involved in developing public policies to regulate cable television.

D. General

Coates, J. F. The Future of Telecommunications, DM, January 1978, pp. 86-93.

This paper focuses on two questions: Why is the future of telecommunications in public policy of importance, and secondly what are the issues and approaches that might be usefully brought to bear on this problem?

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V. INTERNATIONAL

A. Australia

Telecom Australia. Telecom 2000: An Exploration of the Long-Term Development of Telecommunications in Australia. Melbourne, Australia: Australian Government Printing Unit, 1975.

This report to the Australian Telecommunications Commission examines the future of telecommunications in Australia over the next twenty-five years. The report looks at the future of various communications technologies in Australia, including R.F. spectrum and mobile services, cable T.V., computers and communication, and visual telecommunications, and makes specific recommendations to the Commission for research and operational management. The report also studies the impacts of social, economic, and technical trends on telecommunications and speculates on the future role of the Telecommunications Authority. The report is issued as a guide to possible directions in Australia's social, economic, and technical futures to the year 2000.

Telecom Australia. Outcomes from the Telecom 2000 Report. Melbourne, Australia: Victoria Printing, 1978.

This report represents a further stage in the work of the National Telecommunications Planning Branch in looking at the future of telecommunications in Australia. This report incorporates comments from the Telecom 2000 report and raises several new issues covering economics, business, and telecommunications technology. The report provides a summary of the recommendations of the Telecom 2000 report accepted and rejected by the Commission and examines the social bases and framework of the Telecom 2000 report.

Telecom Australia. Seminar on Social Research and Telecommunications Planning: Background Papers and Proceedings. Melbourne, Australia: Victoria Printing, 1979.

The two volumes contain the papers and proceedings of Telecom's first seminar on policy research, corporate planning, and policy coordination. Several of the papers examine the responsibilities and social impacts of Telecom while other papers provide a more general analysis of the impact of telecommunications on the economy, employment, education, user attitudes, and social order. The proceedings elaborate on the issues presented in the papers with specific recommendations for further research.

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Telecom, Australia. Seminar on Social Research and Telecommunications Planning: Background Papers and Proceedings. 2 volumes. Melbourne, Australia: Victoria Printing, 1980.

The background papers and proceedings of Telecom's second seminar examine the relationship of Australia's Telecom policies to other public institutions in Australia. The papers explore how social trends and community concerns affect Telecom development and further explore the impacts of Telecom on Australian society. Specific topics include the effects of telecommunications in Australia on development, community, and environmental public policy making, energy demands, social and welfare services, and Australian industry. The proceedings contain the recommendations of the seminar which include increased coordination with the Australian government, further study of the social and energy impacts of Telecom, and encouragement of greater open market activity.

B. Canada

Bedford, M. T. A Technology Assessment of Future Residence Communication Services. 2 volumes. Canada: Bell Canada, 1976.

The report studies the impact of future residence communication services on the attitudes and behavior of Canadian householders. Using a derivative of the Delphi technique (SPRITE) for questioning experts, the report provides segments of expert views on the impacts of remote shopping, banking, work centers, medical diagnosis, political participation, and electronic home surveillance. Impacts analyzed include time allocations, interpersonal relations, privacy, and dependence on the technology.

C. France

Nora, S. and A. Minc. The Computerization of Society. Cambridge, Massachusetts: MIT Press, 1980.

The authors describe the challenge to French society of the social and technical innovations resulting from the development of telematics. Written as a report to the President of France, the authors propose a national policy for telematics to deal with the many anticipated changes. The report examines the possibility of the restructuring of French politics and the decentralization of French society as a result of large-scale telematics.

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White, C. E. Progress in French Telecommunications Services, Telecommunications, March 1980, 61-77.

This article reports on the present status of French telecommunications and its plans for the period 1980-85. It describes how telecommunications developed in France, the most recent technical advances, and the projected developments for the next five years. The article describes several new services including TRANSPAC--a national data transmission service, mobile telephones, telefax, and its new satellite telecommunications service, Telecom 1, which will be in operation in 1983. The article ends with a brief survey of leading French telecom manufacturers.

D. Great Britain

Barron, I. and R. Curnow. The Future with Microelectronics: Forecasting the Effects of Information Technology. New York: Nichols Publishing Company, 1979.

This report, prepared for the British Government's Department of Industry, assesses future developments in computing, its impacts on society, and the policy implications. It describes the general trend in society toward the information economy, future developments in telematic technologies, and the structure of the international computing industry with particular attention to Britain's role. The wide number of uses of information technologies are described and their impacts on employment and economic growth are analyzed. Several policy recommendations are made to the British government on investment, monitoring, regulation, and oversight.

Marsh, P. Communications for the Information Age, New Scientist, October 23, 1980, 235-238.

This article provides a general overview of the development and installation of Britain's new telecommunications network, System X. Included in the article is information concerning costs, capacity increases, and the constraints on converting Britain's existing network. Adjunct articles provide more specific information on how the technology works.

Williamson, J. Crossed Lines for Telephone Exporters, New Scientist, October 23, 1980, 238-240.

This article describes Britain's race to gain a share of the world's "open" market for telephone equipment. The author describes BTS's (British Telecommunications Systems) efforts to sell System X overseas, and its competitors from other countries. Comparisons of market appeal and technical merit are made among the systems.

E. Japan

Masuda, Y. The Information Society as Post-Industrial Society. Tokyo, Japan: Institute for the Information Society, 1980.

This book describes Japan's $65 billion computer-usage development plan scheduled for completion in 1985. The book projects the emergence of the new information society in Japan and the Western World and discusses the likely human behavior, social, and global changes in response to the information society. The author projects the evolution of voluntary communities, a new time value, and the potential of a computer utopia.

F. Third World

Polishuk, P. and M. A. O'Bryant, eds. Exposition Proceedings Volume 1 and 2: Telecommunications and Economic Development. Dedham, Massachusetts: Horizon House International, 1977.

The two volumes are a compilation of 200 papers presented at the first International Telecommunication Exposition in Atlanta, Georgia, on October 9-15, 1977. Written from the perspective and experience of Third World countries, the authors cover a wide range of telecommunications issues, including telecommunication needs in developing countries, recent advances in satellites, fiber optics, mobile and data communication systems, and more general discussions on the economics and social impacts of telecommunications and telecommunications policy.

G. West Germany

White, C. E. German Telecommunications--a Matter of Pride, Telecommunications, October 1980, 35-53.

The article examines the present telecommunications industry in West Germany and its prospects for the decade ahead. The article covers the specific needs of Germany and the constraints on telecommunications development within Germany. The Bundespost's views on the development of digital technologies, broadband networks, and direct broadcasting are provided along with brief descriptions of Germany's R & D program in telecommunications.

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VI. RESEARCH AND POLICY ISSUES

Bushkin, A. A. and J. H. Yurow. The Foundations of United States Information Policy: A United States Government Submission to the High-Level Conference on Information, Computer and Communications Policy, Organization for Economic Cooperation and Development. NTIA--SP-80-8, U.S. Department of Commerce, June 1980.

This 17-page booklet is important for those interested in analyzing the basic premises and issues underlying U.S. policy in the field of communications. The paper discusses information's properties (resource, commodity, mediator, force for preservation or change) and the ways in which these properties influence the formulation of policy. Since there is no one policy in the United States for information, the report divides existing policy into two categories: "(1) the legal foundations of information dissemination and access; and (2) the economics and management of information". (p. 4) These categories are then broken down into sub-categories as the discussion highlights the tradeoffs inherent in policy formulation: First Amendment rights versus the need for subsidizing some citizens' access to information services. Information management as a component of information policy is briefly discussed.

Coates, J. F. Aspects of Innovation: Public Policy Issues in Telecommunications Development, Telecommunications Policy, June 1977, pp. 196-202.

The article considers the potential for innovation in various telecommunication technologies. After discussing possible futures, Coates analyzes the implications of a general model of change associated with the introduction of a major technology, and concludes by stressing the urgent need for research aimed at anticipating desirable and undesirable impacts.

Daly, R. F. and D. L. Nielson. A Review of National Security-Emergency Preparedness Telecommunications Policy. Menlo Park, California: Stanford Research Institute, February 1981.

This report, prepared for the National Communication System, is designed to review domestic telecommunications policy, the structures and institutions involved in a national security/emergency preparedness (NS/EP) telecommunications policy, and to propose policy options which might be developed to bring capabilities in line with objectives.

The report analyzes such issues as the tension between policies promoting deregulation and competition and the need for industry firms to cooperate in certain areas if NS/EP goals are to be met. Also studied is the fragmented nature of responsibility for telecommunications policy development. The common

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denominator in the problem areas is that government has chosen to use the common carriers as the basis for its communications, raising many questions: vulnerability, changes in the technologies, changes in the industry, and so on.

Panel on Telecommunications Research Committee on Telecommunications National Academy of Engineering. Telecommunications Research in the United States and Selected Foreign Countries. 2 vols. Washington, D.C., 1973.

This document reports on the status and trends in telecommunications research in the U.S. and in other industrialized countries as of 1973. Volume 1 contains the summary conclusions of the research statements in Volume 2 and is broken down into categories on human factors; terminal sensors and displays; transmission, modulation and coding; switching and routing; processing and storage. The report also includes a brief discussion of research on social impacts of telecommunications and the impacts on foreign trade in telecommunications.

Pelton, J. N. Global Communications Satellite Policy: INTELSAT, Politics and Functionalism. Mt. Airy, Maryland: London Books, 1974.

This very theoretical book examines the establishment and operation of INTELSAT--the International Telecommunications Satellite Organization. It analyzes the operation of INTELSAT from a functionalist perspective of international affairs and it discusses the use of INTELSAT as a model of international scientific cooperation. It also discusses INTELSAT's relationship to multinational enterprises and organizations.

Smith, R. L. The Wired Nation: Cable T.V.: The Electronic Communications Highway. New York: Harper and Row, Publishers, 1972.

First written in 1970, this book is one of the earliest attempts to address the many public policies issues surrounding the future of cable television. Written for the layperson, it examines the growth of the cable industry, the need for government regulations, and questions of equal access to cable. It describes the cable technology, and identifies the important industry and government stakeholders in the coming power struggles over cable T.V.

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APPENDIX B

METHODOLOGY USED IN THE STUDY

INTRODUCTION

Identifying the future impacts of a still developing technology is an exercise in pattern recognition. It is much easier to look backward and see the clues that were given than to separate them from the ground beforehand. Although this is a difficult task, and as much an art as a science, efforts to identify the long-range impacts of a technology should be thorough, systematic, and public in order to rise above the level of mere speculation.

In telematics we are dealing with a set of related technologies rather than one technology. This is a help and a hindrance. In assessing the long-range effects of a cluster of technologies we must work at a certain level of generality. Yet, aggregation helps focus on functions and capabilities—important drivers of the effects of telematics (see Section 1). Aggregation also allows for give-and-take among specific technologies within the set. The impact analysis, although less technology specific, is thus more robust.

The development of a technology is influenced in many important ways by other trends and events in society. Conversely, technologies can affect many aspects of society. Some technologies have broader societal connections than others. Telematic technologies are central to our society; a major change in telematics affects every aspect of our lives. Thus, in searching for the environmental effects of telematics we must cast the net widely.

STRATEGIES

Our strategies for identifying the effects of telematics emphasize patterns of societal change, technological systems, and adoption of technology's development from initiation and implementation through closedown and obsolescence. Each phase places different demands on resources; capital, labor, land, energy, materials, environment, skills, and institutions. Exhibit B-1 is a matrix showing the phases of technology's development against the resources required. This matrix can guide the search for impacts of a technology's development. One can modify this search focusing on groups of people who may be affected by technological development and identifying possible impacts on them.

How a technology is adopted affects its consequences for society. Our second strategy for identifying impacts focuses on the stages of adoption. As Section 1 illustrated, a technology's impacts occur in three phases:

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EXHIBIT B-1: PHASED DEMAND MATRIX FOR THE IDENTIFICATION OF POTENTIAL IMPACTS

PHASE/DEVELOPMENT	DEMANDS ON: Capital	Labor	Land	Energy	Materials	Environment	Skills	Institutions
Initiation								
Objectives, policy, priorities								
R&D: basic, applied								
Innovation: technical, legal, etc.								
Planning, design								
Pilot plants								
Demonstration projects								
Implementation								
Capital investment								
Siting								
Procurement								
Construction								
Operation								
Inputs								
Processing								
Products								
By-products								
Emissions								
Transportation								
Utilization								
Dissemination, use								
Misuse, abuse								
Closedown, Obsolescence								

Prepared by Vary Taylor Coates, Ph.D. at The George Washington University

EXHIBIT B-1: PHASED DEMAND MATRIX FOR THE IDENTIFICATION OF POTENTIAL IMPACTS

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1) substitution for another technology, 2) adaptation within systems to make better use of the new technology, and 3) new capabilities inherent in the technology are developed which may go far beyond the original substitution. Some methods for identifying impacts, such as relevance and impact trees, are useful for detecting possible first, second, third, and higher order impacts of the adoption of a technology.

The development and adoption of a technology depends on societal trends or events in society which influence attitudes toward the technology, focus attention on the technology, or change the social value of its development. These external trends and events shape the development and adoption of a technology and thereby affect its impacts. Thus, a third strategy for identifying impacts enumerates societal trends and their combinations and analyzes how they may affect the development of the technology. Matrices, checklists, cross impact analysis, and similar techniques are quite useful in employing this strategy.

To recap, the three primary strategies used in this study for identifying the probable future impacts of telematics are: adoption phases, development cycle, and external trends. We also use a secondary strategy of systematically collecting opinions and research regarding impacts through methods such as literature reviews, brainstorming, and workshops.

METHODS USED IN THIS STUDY

Exhibit B-2 lists a number of methods for identifying impacts and indicates which of them are used in this assessment. Those not used either require data which is more quantitative than is available for the effects of telematics or involve procedures more elaborate than warranted by a mini assessment. The following describes the methods that were used in the assessment.

Compilation of prior work. A comprehensive review was done of the literature in five areas: the state-of-the-art of specific telematic technologies; social, economic, political, and technological trends which will influence the context of the development of telematics; treatments of the issues and affected parties in national information policy formulation; the criteria for use in formulating a research agenda; and related research in progress. The literature of telematics is quite extensive. The literature is not evenly distributed. The treatment of some topics, such as the technologies and their immediate applications, are represented by thousands of items. Yet there is little on other important questions such as policy issues, long-range impacts, and stakeholders. Over a thousand items were examined, and many more references were reviewed. A carefully selected and annotated bibliography of about a hundred items is included as Appendix A.

This review was supplemented by a customized search of research in progress by the Smithsonian Institution's Scientific Information Exchange. The Exchange's files cover all the research in progress in the United States which is not classified. The search yielded about 1000 projects. These projects form the basis of the findings in Section 5 regarding important

EXHIBIT B-2: METHODS USED FOR IDENTIFICATION OF IMPACTS

Methods Used In This Study*

- Compilation of prior work
- Scenarios
- Checklists
- Relevance Trees
- Trend extrapolation and analysis
- Signed digraph
- Brainstorming
- Historical analogy
- Workshops

Methods Not Used In This Study

- Historical surveys
- Systems Analysis
- Simulation
- Modeling
- Hearings
- Field Investigations
- Physical Models
- Delphi
- Cross Impact Analysis
- KSIM
- Dynamic Modeling
- Fault Tree Analysis
- Moot Courts
- Syncons

research which is and is not already being pursued.

In addition to the searches of literature and research in progress, questions on related research were put to over 80 experts. Their responses were helpful in guiding us to additional information and confirming our conclusions about existing research.

Scenarios. To aid in forming a holistic concept of life in a telematics-rich future, four scenarios were prepared. Each focused on a segment of life in the U.S. in about 2005. In one, the theme of physical decentralization of the population is played out. Another explores the impact of intensive application of telematics to agriculture and rural life. A third illustrates a day in the life of an average worker, and brings in detail on the organization of work in the office or factory of the future. The final one, contrary to the other three, focuses on the unsettling aspects of telematics. It projects a future when a telematics-intense society starts to break down, and more telematics is mobilized to maintain social control.

The scenarios were one basis for the team's first workshop in which the group identified the possible impacts of telematics and conjectured about their interactive effects. The scenarios are available from the authors.

Checklists. Several checklists were used to generate possible impacts of telematics. They were a useful stimulus both for project staff and for the workshop participants. There were several types: checklists of traditional, new, and imaginary telematic devices; possible impact areas for telematics; social, economic, and political trends; and methods for identifying impacts.

Relevance tree. A form of relevance tree called a future wheel was used to help structure the search for higher order impacts. Using the future wheel one starts with a technology or set of technologies and proceeds to identify ways it might substitute for other technologies. Additional rounds elicited impacts. The interrelated structure of the future wheel allows impacts resulting from the interactions of other effects to emerge.

Trend analysis. A wide-ranging, thorough search to identify as many social, economic, political, and technological trends as possible was carried out. They were analyzed separately and in combinations to project their impact upon one another and upon the development and application of telematics technologies.

Signed digraph. Signed digraphs show the inhibiting and enhancing effects of variables on one another. They are most useful in initial scoping analysis and analysis of non-quantifiable impacts and trends. A signed digraph procedure contributed to the trend analysis described above.

Brainstorming. Brainstorming is a structured means for generating lists of impacts. Freewheeling thinking is encouraged, criticism is discouraged. Throughout the project, the staff speculated, individually or in groups, about potential effects of telematics. These speculations led to further analyses and to decisions on the significance of the purported effects.

Brainstorming was particularly useful in the project workshops for identifying impacts, and proposing selection, criteria, or policy recommendations.

Historical analogy. A retrospective technology assessment of submarine telegraph proved helpful in its analysis of political, military, and diplomatic impacts of another form of telecommunications.

WORKSHOPS: A KEY PROJECT TECHNIQUE

Grasping the likely interaction of future trends with one another and with developing technologies is not easy. People are able to hold in mind and manipulate only a few concepts at a time. Computers can enhance the ability to work with multiple trends, variables, or concepts. However, the methods still rely on human judgment. Hence, we encounter the classical difficulties in reasoning:

- to identify one's assumptions correctly,
- to resist focusing only on the more visible or tractable elements,
- to make appropriate analogies and generalizations,
- to distinguish important from trivial elements,
- to resist overquantification,
- to grapple with the unquantifiable.

Given the reliance on human judgment, the overriding difficulty in identifying impacts, is projecting beyond the assumptions and boundaries that structure our understanding of the present while holding firmly to the principles of sound thinking. Staying within present frameworks makes it difficult to see farther than the effects of the substitution phase of a technology to the higher order impacts. Even in the best circumstances, few people are likely to overcome these difficulties in more than a few areas. Therefore it is important to involve as many, diverse thinkers as possible in the identification of impacts. This is especially true when dealing with complex social technologies apt to have pervasive impacts on society. For this reason a major focus of the project was workshops.

After the initial analysis of the state-of-the-art of telematics technologies two day-long workshops were convened. Each one included about 20 subject experts representing a wide range of disciplines and organizations. Exhibit B-3 lists the participants. These groups addressed the impacts of telematics and criteria for assessing their importance. Each group began by responding to a workshop paper containing descriptions of present and future telematic systems, and the four scenarios which were described above. During the day they also worked in small groups using a variety of techniques, including future wheels to identify impacts of telematics. The workshops also elicited valuable information and guidance on criteria for sorting among the impacts in terms of their importance to EPA and the government in general.

EXHIBIT B-3: PARTICIPANTS IN THE MID-PROJECT WORKSHOPS

Jessie Bernard, sociologist
Clem Bezold, Antioch Law School
Gail Crotts, National Public Radio
Marie Cummings, National Association of Counties
Anne Cyr, U.S. Department of Labor
Michael Dymmel, Communications Workers of America
John P. Eberhard, architect
Don Dement, NASA
Steven Doyle, (formerly) Office of Technology Assessment
Bernard Finn, National Museum of American History
Kenneth Friedman, U.S. Department of Energy
Mary Margaret Jenior, U.S. Department of Energy
Thomas Joyce, U.S. Department of Labor
Jerry Kidd, University of Maryland
Gregory Kearsley, HUMRRO
Gloria Kemenske, National Institute of Child Health & Human Development
Morris Levin, EPA/OSASS
Mary Jo Manning, (formerly) Senate Commerce Committee Subcommittee on Communications
William F. Mason, The Mitre Corporation
Frank Meeker, Attorney
Arthur Melmed, National Institute of Education
Andrew Molnar, National Science Foundation
Jonathan Moreno, Department of Philosophy, George Washington University
Jay Muzychenko, International City Management Association
Larry Oppenheimer, Congressional Budget Office
Chuck Portaluppi, Motorola
Lawrence Regens, EPA/OSASS
John Richardson, National Research Council, National Academy of Sciences
Alan Siegel, U.S. Department of Housing and Urban Development
Nathaniel Spiller, Solicitor's Office, U.S. Department of Labor
Charlotte Travieso, U.S. Department of Agriculture
Eldon Weeks, U.S. Department of Agriculture

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The workshops yielded valuable information on:

- the description of the technologies,
- the usefulness of the scenarios,
- impacts,
- criteria for sorting impacts,
- the analysis of the stakeholders and policy process.

A workshop to review the final report was also held. There was some overlap with the two earlier workshops. The attendees are noted in Exhibit B-4.

HOW THE METHODS RELATE TO THE REPORT

Following the mid-project workshops, the trend analysis was performed as described above. This trend analysis and the revised description of the technologies were used in concert to produce the impact analysis which forms Section 5. The impacts were systematically drawn out using all of the methodologies described above. They were cross-checked by crossing the list of new capabilities which appear at the end of the technologies chapter (Section 3) with the list of key trends which are developed in the trend analysis (Section 4).

The impacts were then used to identify and analyze the stakeholders and issues (Section 6). In this process, conclusions began to emerge. The analysis continued to build through the consideration of kinds of criteria which EPA/OSASS might use to inform their decision about appropriate research in this area, to the eventual conclusions and recommendations which form the final two chapters (Sections 7 and 8).

EXHIBIT B-4: PARTICIPANTS IN REVIEW WORKSHOP

Robert Cleveland, FCC
Dennis Dobbin, NIOSH
Sam Fordyce, NASA
G. Patrick Johnson, National Science Foundation
Christopher Jones, Institute for Alternative Futures
Morris Levin, EPA/OSASS
Randy Lumb, IBM
Basil H. Manns, EPA/OSASS
Richard Marston, National Research Council
William F. Mason, The Mitre Corporation
Elliot C. McEntee, Federal Reserve Board
Roman Mrozinski, National Research Council
Larry Oppenheimer, Congressional Budget Office
James L. Regens, EPA/OSASS
John Richardson, National Research Council
Alan Siegel, HUD
John Urban, International City Management Association
Eldon Weeks, USDA
Fred Weingarten, Office of Technology Assessment

On completion of the draft final report in September 1981, it was submitted to 20 reviewers soliciting written or other comments. Useful reviews were received from:

Don R. Justesen, Veterans Administration
Robert Cleveland, FCC
G. Patrick Johnson, NSF
Alan Siegel, HUD
Michael Dymmel, Communications Workers of America